

THE INFLUENCE OF FOUNDATION PHYSICS ON THE PERFORMANCE OF
STUDENTS IN PHYSICS I AT SEVERAL SOUTH AFRICAN UNIVERSITIES

by

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I declare that

THE INFLUENCE OF FOUNDATION PHYSICS ON THE PERFORMANCE OF
STUDENTS IN PHYSICS I AT SEVERAL SOUTH AFRICAN UNIVERSITIES

is my own work and that all the sources that I have used or quoted have been
indicated and acknowledged by means of complete references.

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(MR F J MUNDALAMO)

.....
DATE

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Abstract

Few South African students pass Grade 12 Physical Science with symbols required by university science, engineering and health science faculties. A large number of students who sit for Grade 12 Physical Science and Mathematics exams pass with symbols that are well below those required by the mainstream science courses at South African universities.

Most South African universities have introduced Science Foundation Programmes with the aim of upgrading those students who failed to obtain university entrance symbols in the relevant subjects. Amongst the courses offered in Science Foundation Programmes is Foundation Physics. This study investigates the influence of Foundation Physics in order to find out if the programmes in different institutions are successful in empowering the students who failed to get the required entrance mark in Grade 12 Physical Science.

Four South African Historically Black universities participated in this study. The Force and Motion Conceptual Evaluation test (FMCE) (Thornton & Sokoloff, 1998) and mechanics marks were used to assess students' understanding of Newtonian mechanics. Data was analyzed from socio-cultural perspective. A total of 194 students participated in the study. Two groups of students were compared, i.e. those who did Foundation Physics (Foundation group) and those who did not do Foundation Physics (non-Foundation group). The students were tested after they had completed a mechanics module, which forms a great foundation of Physics I (Introductory Physics). Two focus group interviews were held with selected Foundation and non-Foundation students per institution. Students voiced their experiences in Physics I and Foundation Physics. Students were chosen to represent focus groups according to their performance in the FMCE test. Mechanics class performances were also used to evaluate students' performance. In order to establish how Foundation Physics is taught, Foundation Physics Lecturer interviews were conducted at all four institutions.

Analysis of data showed that both Foundation and non-Foundation students performed equally in Physics I mechanics module. Foundation group performed better than the non-Foundation group in the FMCE, which is a conceptual test. Foundation

Physics lecturers indicated that there were some differences in the way mechanics was taught in Physics I and Foundation Physics. These differences affected students' performance. The lecturers also indicated that there was minimal interaction between Physics I lecturers and Foundation Physics lecturers pertaining to the teaching of the two courses.

What influence does Foundation Physics have on the performance of students in Physics I? This study found that students who did Foundation Physics performed better than those who did not do Foundation Physics in conceptual questions and both the groups perform equally in questions that require memorizing and calculations. This implies that Foundation Physics courses are empowering the students to perform well in Physics I. However, as it is evidenced by this research, the differences in assessment in Physics I and Foundation Physics courses in some institutions hampers Foundation Physics students' learning, because the questions asked require them to memorize without understanding, something they are not used to.

The researcher recommends that Foundation Physics staff and Physics I staff should start communicating, not only about how Foundation Physics should be run as was the case in the past, but also on how best Physics I should be run. This might help in making sure that the two courses are assessed similarly at one institution.

Key terms

Foundation physics; physics; interviews; focus groups; science foundation programme; practicals; South African universities; Grade 12; matric.

Chapter 1: Introduction	1
1.1 Motivation	1
1.2 Contributions of this thesis	3
1.3 Organization of this thesis	3
Chapter 2: Literature review	4
2.1 Introduction	4
2.2 Government policy on mathematics and physical science	4
2.3 Physics in South Africa	5
2.4 Physics research institutes	7
2.5 Job opportunities for graduates in physics	7
2.6 Attitudes and beliefs of students	8
2.7 Students' performance in mathematics and physical science	9
2.8 Rural and urban schools effect	10
2.9 Black and White schools effect	11
2.10 Language and science	11
2.11 Foundation Programmes	13
Background	13
How to increase number of students entering mainstream Physics	13
Different Foundation Programmes	13
Justification of Foundation Physics	14
2.12 Foundation Physics and Physics I curricula	15
Teaching and learning strategies	15
Misconceptions	16
Cooperation between Foundation Physics and Physics I	17
2.13 Teaching and learning physics	18
A constructivist perspective	18
A sociocultural perspective	18
Learning strategies	19
Factors affecting achievement	19
Mathematical numeracy in physics	19
Physics content	20
Expert physicists versus beginning students	20
2.14 Summary	21
Chapter 3: Research Process and Methods	22
3.1 Introduction	22
3.2 Study design	22
3.3 Study area	22
3.4 Participants	23
3.5 Instruments and data sources	24
FMCE questionnaire	25
Interviews	26
Mechanics marks	27
Foundation Physics student guides	28
3.6 Data collection methods	28
FMCE standardized test	29
Mechanics exams	29
Student focus group interviews	29
Foundation Physics lecturer interviews	31
3.7 Ethical issues	31
3.8 Practical issues arising during the field work	31
3.9 Data analysis	32
Quantitative data	32
Qualitative data	33

Chapter 4: Mechanics Tests and Course Results	35
4.1 Introduction	35
4.2 Respondent demographics	39
Gender	39
Age	40
Nationality	41
Year of matriculation	42
Physical Science symbol	43
Foundation Physics	44
Province of matriculation	45
Province of residence for Foundation Physics students	46
Sector of school where student matriculated	47
Area where school of matriculation is situated	48
4.3 Respondent performance	51
Foundation and non-Foundation Physics FMCE performance	52
4.4 Summary	63
Chapter 5: Interviews with students and lecturers	64
5.1 Introduction	64
5.2 Grade 12 Physics background	66
5.3 What students aim to achieve with Physics	67
5.4 What students expected Physics I to be like	68
5.5 What helped students to understand Physics I	70
5.6 Lecture section and lecturers	72
5.7 The effectiveness of the lecture section	73
5.8 Discussions in class	75
5.9 How do discussions in class help students?	76
5.10 The practicals	77
5.11 Tutorials and tutors	80
5.12 Exercises, tests and exams	83
5.13 Students' expectations and attitudes in Physics I	84
5.14 Acquired skills	87
5.15 Conceptual understanding	88
5.16 Students' confidence	89
5.17 Physics workload	92
5.18 The role of Foundation Physics in learning Physics I	93
5.19 Foundation Physics Lecturer Interviews	94
Components that form Foundation Physics course	95
Teaching approach in Foundation Physics	95
Topics covered in Foundation Physics	96
Other elements covered that are not physics	96
Emphasis in Foundation Physics and emphasis in Physics I	97
Interaction between Foundation Physics and Physics I lecturers	98
Performance of Foundation Physics students in Physics I	99
Performance of Foundation Physics students in the gravitational acceleration	99
5.20 Summary	102
Chapter 6: Conclusions	108
6.1 Introduction	108
6.2 Research questions	108
6.3 Summary of the main findings	109
6.4 Limitations of the study	110
6.5 Recommendations for further research	111
Bibliography	112

Appendices	117
Appendix A: Physics I Student Interview Protocol	117
Appendix B: Foundation Physics Lecturer Interview Protocol	122
Appendix C: The FMCE questionnaire	123
Appendix D: Students' Biographical Information	130
Appendix E: Physics I Mechanics Examination Papers (2004)	132

Chapter 1

Introduction

This chapter presents the motivation behind the thesis, and defines the fundamental problem considered. The remaining chapters are outlined.

1.1 Motivation

The number of students who take physics as one of their major subjects is decreasing, not only in South Africa, but throughout the world (Thacker, 2003). In South Africa, students who pass Grade 12 Physical Science with university entrance symbols are persistently very small in number (Bernstein, 2005). All South African universities have to compete for such small student numbers. It is, however, pleasing to note that almost all South African universities have introduced Science Foundation Programmes with the aim of assisting those students who failed to acquire university entrance symbols. Foundation Physics is one of the courses offered in the Foundation programmes aimed at those students who did not attain good symbols to enable them to enrol for Physics I (Introductory Physics). Students who are enrolled for Foundation Physics will be in the same class of Physics I together with students who qualify for Physics I using Grade 12 symbol in the following year. The aim of this study is to evaluate how Foundation Physics influenced the performance of Foundation students once they enrolled for Physics I compared to direct entry students.

The study was limited to the performance of students in the mechanics module of Physics I. Just as the researcher has chosen a sample of institutions, mechanics was chosen as a representative module. There are several reasons for selecting mechanics. Firstly, mechanics is part of the core of all Physics I courses. It forms the Foundation for many later topics. Secondly, a number of researchers, such as McDermott McDermott *et al.* (1987) and Thornton & Sokoloff (1998), have identified a number of misconceptions and other problems in mechanics. From the researcher's teaching

experience, students who do not have a good grasp of mechanics are likely to perform poorly in other physics modules. McDermott *et al.* (1987) looked at students' difficulties in connecting graphs to physics even though examples were from kinematics and not the whole of physics. Thornton and Sokoloff (1998) pointed out that the Force and Motion Conceptual Evaluation (FMCE), the instrument that was also used in this study, is used to evaluate student learning in introductory physics courses, even though they knew it only evaluates student learning in mechanics. Thus other researchers have used performance in mechanics as an indicator of performance in Physics I. Similarly, in this study performance in the mechanics module is used as an indicator of performance in Physics I.

The topic of this research is “The influence of Foundation physics on the performance of students in Physics I at several South African universities”. The purpose of this research is to provide answers to the following research questions:

- a) What influence does Foundation Physics have on students' performance in Physics I?
- b) In what ways do the knowledge and skills of students who have been through a Foundation Physics course differ from other Physics I students?

It is important to make sure that as many students as possible enroll for physics since it is the backbone of most engineering qualifications, as well as being an important component in health science degrees. The South African economy, as well as that of the whole world, therefore depends on good human resources amongst whom there should be a good representation of physics trained personnel, i.e. those who are just literate in physics, as well as physicists.

Foundation Physics might be a solution that could be used to increase student numbers in physics. The problem of student numbers can only be solved using this approach if Foundation physics influences students (the Foundation group) to perform well in Physics I. In order to find out if Foundation Physics influences the Foundation group to perform well, this group is compared with the students who passed matric with good grades (the non-Foundation group) and entered Physics I directly. The two groups are compared during the period that they are registered for Physics I.

The importance of Foundation Physics in preparing students to succeed in Physics I at South African universities has not been thoroughly investigated. This study informs the reader on the differences between the two groups of students, the Foundation and the non-Foundation groups, who are all registered for a Physics I course. It also suggests causes of such differences and provides advice on how those differences can be addressed.

1.2 Contributions of this thesis

The study serves to inform the designers of Foundation Physics and Physics I of different universities about the steps to be followed in making sure that Foundation students succeed in physics. It also provides suggestions to physics lecturers about steps to be followed to make sure that more students continue to major in physics.

1.3 Organization of this thesis

Chapter 2 discusses the literature relating to the study. Chapter 3 explains the research methods that are used to conduct this study. In chapter 4 results from various mechanics assessments are discussed. This chapter compares the Foundation group performance with that of the non-Foundation group. Chapter 5 contains a discussion of the student Focus Group Interviews and Foundation Physics Lecturer Interviews with the aim of understanding the Foundation group in detail. Chapter 6 gives conclusions and recommendations from this study.

Chapter 2

Literature Review

2.1 Introduction

Most South African universities have introduced Science Foundation programmes in order to curb the decline of students taking sciences and to provide a second chance for students from academically disadvantaged backgrounds to study science. This chapter will look at the state of physics in South Africa and what the literature says about studying physics in general and Foundation Physics in particular.

2.2 Government Policy on Mathematics and Physical Science

The National Mathematics, Science and Technology Education Strategy (Department of Education, 2001) identified three key thrusts, i.e. to raise participation and performance by historically disadvantaged learners in Senior Certificate Mathematics and Physical Science; to improve on the number and quality of teachers of mathematics, science and technology; and to provide high quality mathematics, science and technology education from Grade 1 to Grade 12 (Pandor, 2004). This is a very good idea which needs the backing of the tertiary institutions who are the trainers of the school teachers.

There is a need to improve teacher development programmes so that the teachers can be successful in the teaching of maths and science. Bursaries have been put aside to assist students wishing to become teachers of Science and Mathematics through the National Financial Aid Scheme (NSFAS) (Pandor, 2004). If these students do not meet entrance requirements in sciences at tertiary institutions they might enter the Foundation Programmes. The National Framework on Teacher Education provides a clear platform for engaging teaching agencies, especially Higher Education institutions and also clarifies the role of provincial and district officials in the continuing professional development and the ongoing support of teachers (Pandor, 2004).

The strategy also identified schools that will focus on maths and science, the Dinaledi schools. The original number of schools was 102. This number will be increased to 1000 by the year 2009.

2.3 Physics in South Africa

The number of students taking physics as a major subject is declining. Before the 1994 democratic elections, the South African physics community was dominated by whites. The FRD (1996) and the International Panel appointed to investigate the state of physics in South Africa (2004:3) pointed out that in the past, most African pupils did not have the opportunity to choose mathematics and science as subjects at school. This has also been noted by the Minister of Education, Naledi Pandor (2004:1), who indicates that

Mathematics and science have for a long time been a preserve of a select few. Many generations of young people have been denied access into these important subjects because of apartheid and because of the myth that one is born either with or without an ability to handle these subjects.

This situation is changing in South Africa and the problem now is a shortage of qualified science and mathematics teachers at historically black schools. This problem might be solved by increasing the number of students taking science at tertiary level. Some of the physics graduates will then become teachers at schools. However, this is not possible if students do not meet entrance requirements at university.

The International Panel (2004:2) report says “Physics in South Africa is ill” and also indicates that:

The past decade or two has seen a decline in student numbers in Physics at all levels of study in tertiary education. University departments that once produced a torrent of excellent physicists have been reduced to 3rd year classes of one or two. While student numbers at universities and technikons overall have risen during the last decade, what were major Physics departments can no longer guarantee that they will have an Honours class. The pipeline from school to profession is producing only a trickle of talented physicists. Pupils of Physical Science at school have declined in number. The teaching of Mathematics and Science at school have declined, in general, [teaching of the two subjects at school is] in dire straits. There is a shortage of teachers who have thorough subject knowledge, as well as love for the subject that they can transmit to their learners. The small pool of those students entering tertiary education with the required level of knowledge and understanding of mathematics and Physics is skewed in its racial and gender composition (thereby leading to relatively slow transformation), and [the small pool of students] is attracted away from physics by the very real rewards to be found for a qualification in subjects such as Computer Science, Actuarial

Science, and Business Science, apart the longstanding attractions of Medicine and Engineering.

A few decades back, the state supported physics with the aim of strengthening defence and nuclear capability. The focus of the government has now shifted to fight against AIDS, poverty, crime, etc., which are seen as being based on “soft technology” and social sciences. The role of physics is not that visible or needed in this scenario. The International Panel (2004) further indicates that the role of Physics to the state is not as obvious as it was in the past. However, the South African government should value physics because it forms a base for most engineering and health sciences, otherwise all these fields might also vanish.

However, the introduction of Foundation Physics in tertiary institutions might help to solve those problems by admitting those students that did not perform well in high school physical science.

Arndt (1990) argues that in order to drive the economy that leads to wealth creation and improve the quality of life for all South Africans there should be team effort between scientists, engineers and technicians. Arndt further suggests that institutions should adopt dynamic and flexible systems so as to attract and train the people needed.

The International Panel (2004) notes that:

Although South Africa is not one of the world's leading countries in science and technology, it is clearly the leader in sub-Saharan Africa, and indeed, in many areas of research and development in Africa as a whole.

One of the reasons why there is a need to improve and encourage science in South Africa is that “A greater number of science graduates results in a more skilled and therefore a more productive work force, which in turn contributes to an internationally more competitive nation and to redressing the balance of trade problems” (Robottom & Hart cited in Muwanga-Zake, 2004).

The report by the International Panel (2004) indicates that physics in schools is perceived as a difficult subject. This is very worrying because both students and school authorities in most cases favour easier subjects or opt to enrol for Standard Grade rather than Higher Grade Physical Science (needed for entry into university science studies) to make sure their students get higher marks in the Matriculation Examination that will raise the name of the institution.

And there is not necessarily a correlation between a lack of resources and dismal maths and science results. Several schools in poor rural communities are thriving because of good leadership and discipline (Financial Mail, 2004:12)."

It is worth noting that maths acts as a key to many opportunities such as "academia, high-tech industries, physics, science and finance" (Pandor, 2004:1). Despite a few successes, the reality is that few African pupils pass mathematics and science in higher grade. For example, in the Western Cape, only 30 black (African) pupils passed mathematics in the higher grade in 2003, and coloured students did not do much better.

2.4 Physics Research institutes

The biggest employers of physicists, for example, the Council for Scientific and Industrial Research (CSIR) and Atomic Energy Corporation (AEC), now known as NECSA, were restructured over the last 20 years (International Panel, 2004). The scientific research base of the CSIR was cut down and was replaced by a consultancy-oriented philosophy. Many of the physicists that were employed by NECSA were recruited by PBMR in 2004 and 2005. This left some openings that need to be filled.

2.5 Job opportunities for graduates in Physics

Outside teaching, there are very few job advertisements for physicists. The International Panel (2004) indicates that the Science Councils now employ a small number of physicists and therefore the students see a lack of employment for those who study physics. Posts that become vacant in academia are often frozen and not advertised or they require more experienced personnel. However, many of the most active researchers are about to retire. There will therefore be more job opportunities

coming up. Other special projects, such as the Pebble Bed Modular Reactor, will require physicists. There are also many jobs that physicists do where the incumbents are not necessarily classified as physicists, including engineering jobs and work in the financial sector. Therefore the lack of jobs for physicists is more a perception than a reality.

2.6 Attitudes and beliefs of students

The attitudes that students come with into the class may influence what they learn in the physics course. There is some difference between individual and intrinsic interest, and situational and extrinsic interest. Situational and extrinsic interest is stimulated by contextual factors such as good teaching that stimulate interest and engagement. The role of situational interest is highly significant in classrooms or courses where students are not interested in the course or are not at all motivated academically (Osborne, 2003).

McCombs cited in Hynd *et al.* (2000) indicates that the students' interest in science affects their motivation, will to learn science and that their past history of science learning affects how they perceive their skill. Teachers should make an effort to tie information to students' interest. Teachers can present information by incorporating real life applications or uses. Students should also be taught to associate information with future goals.

Häussler and Hoffmann cited in Perales-Palacios and Vílchez-González (2002:400) indicate that there is a “well-established decline in the choice of scientific university degrees or lack of interest in studying physics,” and because of this, teachers should reflect on their role as teachers and on the main educational objectives that they would like their students to accomplish.

Some of the reasons why students fail to gain enthusiasm for physics are their home backgrounds (Jennison, 1998, Bleeker & Jacobs, 2004), and the status and remuneration of careers for physicists (Williams *et al.*, 2003:324). According to Williams *et al.* (2003), students' liking of physics decreases at secondary school while their liking of biology remains stable.

A study done for the UK government by ACOST (Advisory Committee on Science and Technology), concluded “that many students had negative attitudes towards science because they perceived their science courses as being difficult and dull, impersonal and abstract, irrelevant to their lives and requiring them to be passive in their learning”. However, students welcomed the active learning and the project work that was being encouraged in some of their courses (Woolnough, 2000). This might be the same in a South African situation and as such students need motivation to choose physics as one of the courses they major in at tertiary level.

Farmer *et al.* cited in Bleeker and Jacobs (2004:99) explained that “women and men in science careers, as compared with those in non-science careers, took more high school elective science courses and aspired to higher prestige careers as adolescents.”

Fonseca & Conboy (1999) found that students’ attitude towards first-year physics was astonishingly negative, especially at the beginning of the year. Students saw little use of physics in their lives or in their future careers. In their study, Fonseca & Conboy (1999:273) further indicated that physics was “perceived as a difficult, dull, uninteresting subject ...” and that they had very low confidence in their own ability to pass the course.

2.7 Students’ performance in Mathematics and Physical Science

A minimum level of mathematical proficiency is usually assumed for Physics I courses, which differs for different institutions. The Minister of Education, Naledi Pandor admitted that she was “quite concerned” about the country’s performance in both maths and science (Govender, 2004). Govender indicates that South African pupils who took part in the 1999 study of Trends in International Mathematics and Science Study, involving 38 countries were in the last position. South Africa came last in the TIMSS results released in 2004 (HSRC, 2004).

According to research by International Association for the Evaluation of Education Achievement, South African pupils are the worst of the 20 countries which participated in mathematics and science (Bolowana, 2004, Sapa, 2004). Other African countries that were part of this survey conducted in 2002 were Egypt, Tunisia,

Morocco, Botswana and Ghana. Even though South Africa is considered the fastest developing nation in Africa, it still performed way below the other five African countries in the survey. Sapa (2004) indicates that causes for South Africa's poor performance include poverty, poor infrastructure and resources, low teacher qualifications and poor learning culture.

The (HRD Review, 2003) data tables (HSRC, 2003) revealed the Senior Certificate Examination average aggregate percentage marks as 41% Higher Grade (HG) and 26% Standard Grade (SG) for mathematics and 41% (HG) and 33% (SG) for physical science.

2.8 Rural and urban schools effect

A survey conducted by Statistics South Africa showed that a higher proportion of urban than rural children aged between six and fifteen years were attending school (Africa *et al.*, 2001). The study further indicates that only 8% of employed people aged 26 years in urban areas had no formal schooling compared to a quarter of employed rural people. By 1996, 47% of African people aged 26 years or more were not economically active and 53% of rural people had no formal education in October 1996. Africa *et al.* (2001) indicate that households situated in rural areas had access to fewer facilities than those situated in urban areas. Where a school is situated says a lot about the performance of students (Ma & Wilkins, 2002).

In their study, Sadler and Tai (2001) found that students from more wealthy communities earned higher grades than those from less wealthy communities. Fewer students from economically poorer communities took physics in high school and poorer communities faced a shortage of well-prepared and experienced science teachers. Schools in poorer communities have a shortage of equipment and are far less likely to have a teacher who exclusively teaches physics (Sadler & Tai, 2001).

Many South African students come from communities and schools where they had little exposure to physics. However, Physics is a prerequisite for so many careers in the sciences and applied sciences and as such a lack of it might hamper their career options (Grayson, 1997a).

Two-thirds of the mathematics higher grade passes are produced by about 24% of high schools, many of them are former Model C schools (Financial Mail, 2004). This is stressed by Naidoo (2004:22) who says that:

The mathematics and science education system has failed dismally to deliver enough school-leavers equipped with higher-grade passes to meet the country's needs.

In the 1970s, the private sector started funding mathematics and science projects in response to the inhuman impact of Bantu education of African learners (Naidoo, 2004).

2.9 Black and White schools effect

The study of Bolowana (2004) revealed that pupils from former white schools performed better than those at former African schools in both maths and science. Grayson (1996) indicates that there are differences between black schools and white schools in South Africa. In black schools there are not enough resources, classrooms are overcrowded, and teachers are under-qualified (Grayson, 1996). However, the situation might now improve since most schools are accommodating pupils of all races.

2.10 Language and science

Improved language use in science can improve science achievement and scientific reasoning (Yore *et al.*, 2003). Black (African) students come from a school system characterized by rote-learning and under-qualified teachers (Hunter, 1990). Though these students are proficient in basic interpersonal communication skills, Hunter says “they usually have not developed cognitive academic language proficiency”. In an effort to eliminate the dominance of one language over another, the South African constitution decided to make all 11 of the country's major languages equal and official (Brock-Utne & Holmarsdottir, 2004). Since the first democratic elections in South Africa, the education legislation has been passed to implement a new school system, introducing the 11 official languages (including a European [English] and a European-based [Afrikaans] language) and a new policy for schools on medium of instruction. According to Brock-Utne & Holmarsdottir (2004):

Despite what may be regarded as a very progressive language in education policy, which in principle enables learners or their guardians to choose the language of instruction, English is used as the medium of instruction from grade 4 onwards. The transition to English is, however, only a policy decided by individual schools and reflects the actual 1979 apartheid language policy. ...According to this policy the whole of primary school as well as secondary school and tertiary education could be conducted in African languages as the languages of instruction.

This is supported by Macquarrie (1969) who recommends the system that was followed in the then Transkei, where mother tongue is taught up to and including Standard II (Grade 4) and thereafter a gradual switch to English or Afrikaans, which then becomes the medium of instruction. However the recommendation that students switch to English and / or Afrikaans as early as grade 4 will not solve the problem because students are failing to communicate in these languages at secondary school and tertiary levels.

Brock-Utne & Holmarsdottir also indicate that it is possible to use English text-books and teach in indigenous languages as is done in some university courses in Norway. Many black South African students have inadequate background in English language and mathematics (Grayson, 1996) and a switch to use of the mother tongues might help.

Developing countries like China have to confront the not so easy task of translating scientific and technological terminology into their own language since these are written in foreign languages (Zhao, 1990). Zhao indicates that, of the terms making up the physics nomenclature of modern Chinese, most items are translated from western languages. Within a few years of the founding of the People's Republic of China, lecturers and textbooks started making use of mother tongue at all levels. Physics education in China benefited a lot from using mother tongue, "especially at lower education levels, and in communicating physics to the general public".

Nyembe (2004) indicated that those who study in their own language can prosper "because it is always easier to learn in one's language". Clerk and Rutherford (2000) pointed out that if a student answers questions incorrectly, one should not jump to the conclusion that true misconceptions are held. The authors further indicate that language should take more of a center stage in science education than it has so far.

2.11 Foundation Programmes

Background

In South Africa, few black students acquire the required symbols for maths and physical science in Grade 12 to gain entry into the mainstream university science courses. For a number of years South Africa had a racially segregated government, where the whites were dominant over blacks in general and in particular over those classified as African. Allie and Buffler (1998) argue that the situation for high school African students with regard to mathematics and science was appallingly bad. Teaching of mathematics, physics and chemistry in many South African schools is in a critical state and many students go to universities with a background of academic disadvantage. These students require an initial period of special help if they are to benefit from the tuition offered (Stanton, 1987). Stanton (1987) argues that there is no point in accepting students for these courses if chances of success are not reasonably good. However, Grayson (1997b) supports the introduction of Foundation programmes to improve the grades of most black students.

How to increase number of students entering mainstream Physics?

Entry into the tertiary Physics stream is in general restricted to those who have obtained appropriate school performance in Mathematics and Physical Science at higher grade levels. However, as the International Panel (2004) points out there is poor quality teaching in many schools, and most universities and universities of technology have introduced some form of academic support programme. Through support programmes (Foundation or Bridging) the institutions can extract candidates who are likely to succeed from the pool of those students who have not satisfied initial entry requirements, i.e. those students who have the potential, but are held back by their poor schooling. As pointed out by the International Panel (2004), Foundation or Bridging programmes are widely operative in South African universities. This brings in large numbers of students from previously disadvantaged communities.

The aim of a Science Foundation Programme (Grayson, 1996, 1997b) is to allow black students to overcome the gap through a year-long passage “from where they are when they enter the university to where they need to be in order to succeed in science (or science-related) degree programmes.” The assumption in the Science Foundation

Programme is that students need to build a foundation for meaningful learning for the first time.

Different Foundation Programmes

These programmes, as the International Panel points out, take a number of different forms. Amongst them are fully fledged Foundation Years, in which students take a number of science subjects, as well as communication. The University of the North Foundation Year (UNIFY), University of Natal Science Foundation Program, and University of Pretoria Foundation Year (UPFY) are examples of Foundation programmes that run for one full academic year (Netshisaulu, 2002). The students who complete a one year Foundation programme will only complete a Bachelor of Science (BSc.) degree after they have completed three extra years. University of the Witwatersrand (Wits) also has a different model, with students spending two years in the College of Science, after which they enter the second year of a BSc.

The Foundation physics course, introduced at the University of Natal was designed to assist talented but disadvantaged students when they come from under-resourced high schools (Grayson, 1997a). This foundation course is developmental in nature, it starts at a slow pace and increases both in pace and level of difficulty as the year progresses. Its curriculum is divided into four components: concepts, cognitive skills, practical skills and equipment (Grayson, 1997a). The University of Cape Town (UCT) started its Science Foundation Programme in the year 1986. The broad aim of this programme is to equip students so that they can meet the demands of a Physics I course (Allie & Buffler, 1998). Two different structures for the Science Foundation Programme were used at UCT. From 1986 to 1990 the Science Foundation Programme was composed of a bridging (Foundation) year wherein students did non-credit courses as preparation of first year of the degree. The structure of the Science Foundation Programme was redesigned in 1990 and was put in place in 1991. The current model of the SFP runs for two years and it offers a combination of non-credit half courses and credit-bearing half courses (Allie & Buffler, 1998).

These differences of approaches raise the question of relative levels attained by students at different institutions. The question of standards is very important for

diversity management (International Panel, 2004). They are overcoming the difficulties produced by the school system.

Justification of Foundation Physics

There is a gap that exists between high school and university in South Africa. Grayson (1996) argues the “gap is wider for students coming out of black schools” and it is unrealistic to expect that students who had poor schooling backgrounds will be able to perform at the same level as students from advantaged backgrounds (Grayson, 1997a). A very interesting feature is that 58% of students who took the Foundation Physics course in Grayson’s study passed physics I on first attempt, as compared with 50% of all other Physics I students.

2.12 Foundation Physics and Physics I Curricula

Teaching and learning strategies

At the University of the North’s UNIFY, the teaching is student centred. A small group of students is required to have contact between themselves and the lecturer as well as greater participation of students in classroom activities than in traditional university teaching. The lecturers encourage students to work out solutions for themselves either on their own or in peer group discussions. In this course, practicals and theory are completely integrated in the teaching and learning process (Netshisaulu, 2002)

Discovery-based learning with Vygotsky-based learning theory is used at the University of Natal Foundation Physics. There is a lot of hands-on learning in the course. The course begins slowly with basic concepts and gets more challenging as the year progresses. Practicals are also part of the course (Grussendorff cited in Netshisaulu, 2002).

Misconceptions

Misconceptions are resistant to change, are the same in different parts of the world, and often differ from the views promoted in school physics (Jenkins, 2000). The role of the teacher should be to evoke students’ misconceptions and to give students experiences that will allow them to change these misconceptions in favour of a

scientific understanding of natural phenomena (Jenkins, 2000). Jenkins points out that a constructivist view of learning does not demand much, as it is possible to engage the minds of learners by using different teaching techniques, “some of which might be described as formal or didactic, rather than informal and exploratory.”

According to Hunt and Minstrell (1997) children’s difficulties with science occur because their prior knowledge is not taken into account and therefore communication barriers between teachers and learners cannot be overcome. It has been shown (Eicsson, Krampe & Tesch-Romer, cited in Hunt & Minstrell, 1997) “that the precondition for remarkable performance is deliberate practice during a long period of time rather than exceptional psychometric intelligence”. Preschool children can talk about the features of an object like size or weight, although their ideas sometimes contradict those of adults (Carey, cited in Hunt & Minstrell, 1997). McCloskey (cited in Hunt & Minstrell, 1997) reports that elementary school children, like many adults, have developed belief systems about falling objects that show some similarity to the medieval impetus theory.

Research cited in Thacker *et al.* (1994) has shown that many students taught Physics I in the standard lecture-recitation format learn to solve quantitative problems well but do not develop an understanding of physics concepts different from their initial common sense misconceptions.

According to Derry (1996), many students and their parents do not share the goals of conceptual understanding and detailed coverage of major scientific principles with school teachers. They prefer schools that provide students with what they need to perform well on standardized tests, which serve as keys to advanced schools and careers. Such tests emphasize breadth of coverage more than depth of understanding. Derry further adds that in reformed classes, small-group methods that require intensive collaboration are frequently used. In most cases collaborative courses are more demanding and time consuming (Rae, 1996) than are traditional ones, and for this reason some students object to them.

The literature in Eryilmaz (2002) call the intuitive beliefs that students develop on their own before attending Physics I by different names. Researchers have called them

misconceptions, preconceptions, alternative conceptions, children's scientific intuitions, children's science, common sense concepts, and spontaneous knowledge. This study will use misconceptions to denote all alternative beliefs students hold before registering in Physics I. According to Eryilmaz (2002), "misconceptions refer only to those beliefs students have that contradict accepted scientific theories". These misconceptions are related to key concepts such as mass, velocity, acceleration, force, etc.; and "fundamental principles and models such as Newton's laws, conservation laws, and others". Mechanics is the most frequently studied section in physics by students. One of the misconceptions that the students have is: to confuse the position and velocity of an object; when two objects have the same position, some students think they have the same velocity as well.

UNIFY Foundation Physics (Netshisaulu, 2002) indicated a lot of misconceptions that students raised, amongst them is "average velocity = change in velocity = instantaneous velocity" and that "motion requires force". Foundation Physics students from the University of Natal thought that the value of g changes sign for downward motion relative to upward motion even though they were taught this at school. These students also confused force and momentum" (Netshisaulu, 2002).

Amongst the misconceptions made by the UPFY students are "that a body needs a net resultant force to keep moving with constant velocity" and "that there is no real difference between velocity and acceleration". This study will focused on four South African institutions named Institution 1, Institution 2, Institution 3, and Institution 4.

Cooperation between Foundation Physics and Physics I

The curriculum of Foundation Physics at the University of the North is mainly an introductory course to Physics I. It does not cover most topics in full. On measurements, various measuring tools are studied without considering their zero readings (Netshisaulu, 2002).

At the University of Natal Foundation Physics is very different from Physics I. Physics I is very conservative and traditional in teaching approach. The Physics I course is not developmental and sees the role of instructor as a passing on of expert knowledge which should be absorbed by learners. There is no communication of foundation staff to try and influence Physics I.

University of Pretoria's Foundation Physics places more emphasis on conceptual understanding and subscribes to the idea that less is more in terms of the amount of physics actually covered. The Foundation Physics lecturers assist in Physics I tutorials and the mainstream Physics staff moderate Foundation Physics papers. The mainstream lecturers at the University of Natal also moderate Foundation Physics exams.

2.13 Teaching and Learning Physics

A Constructivist Perspective

Learning is believed to occur through students actively constructing their own meaning in unique ways as they interact with their learning environment, process different experiences, and build on their existing knowledge (Leder, 1996, Killoran, 2003, Hein, 1991, Ping, 2002).

We learn in relation to what else we know, what we believe, our prejudices and our fears. It is not possible to assimilate new knowledge without having some structure developed from previous knowledge to build on. Motivation is a key component of learning.

A Sociocultural Perspective

This view has its origin in the works of Vygotsky (1978). Learning and meaning-making is the result of social interactions with others or with cultural products such as books and other sources of culture. Learning is regarded as being socially and culturally dependent and can be seen as enculturation. In this perspective, learning is by means of language. Learning physics is seen as “learning to act and talk like a physicist” (Vygotsky, 1978).

Learning strategies

Although the prosperity in western industrialized countries was brought about mainly by the progress in physics, chemistry and engineering (Stern, 1996), these subjects are particularly difficult to learn and hard to teach in school. A lot of instructional efforts in physics do not bear fruit. In a physics class, as Stern (1996) indicates, only a handful of students, mostly males, get a deeper understanding of concepts. In most

cases successful students had already acquired knowledge in the subject matter outside school.

Prosser *et al.* (1996) indicate that even though students say physics is about the study of the physical world, few students approach their studies in terms of seeking to understand the physical world. The authors report that most students thought that success in studying physics was about innate ability and/or hard work, rather than the style of studying. Most students preferred a ‘surface’ approach to learning in terms of attending classes, reviewing notes, learning formulas and doing exercises. Prosser *et al.* further indicate that few students indicated that they were seeking understanding – ‘deep’ approach, relating their knowledge to real world experiences

Factors affecting achievement

Factors that may have a serious effect on students’ achievement (Grayson, 1996:994) are “failure to do homework and lecture preparation, failure to go to an instructor for help if material has not been understood, poor time management (e.g. too much socializing, being unpunctual, poor budgeting of time), becoming dependent on the lecturer, and not studying with peers.” Attitudes that may be detrimental to students include, among others, learning by rote and accepting knowledge received from the teacher as gospel.

Mathematical numeracy in physics

According to Gill (1999:83) “many students of science subjects arrive at university with little facility and less interest in mathematics” although undergraduate courses in physics usually have mathematics as an ancillary subject at least in the first year. These students lack what we might call standard skills, i.e. numeracy, graphicacy and algebraic manipulation. Gill (1999) further indicates that mathematics becomes a powerful tool in physics if it is well understood. To resolve this problem, there should be some communication between physics and mathematics educators.

Since many students are put off physics by the mathematical nature of it, improving students’ mathematical abilities should be the main strategy to improve grades (Raw, 1999). Raw (1999) argues that it is important for students to attempt many questions if they want to become experts at physics or maths because one cannot expect to produce “the miracle of effortless learning”. Raw further recommends that drawing

diagrams can aid students in understanding concepts. Schoenfeld (cited in Raw, 1999) encourages students to present their solutions to problems to the rest of the class for better learning.

Physics content

Brown (1989) argues that Newton's third law should be treated as much more significant part of an introductory physics course since it is important for developing the students' qualitative concept of force. High school students enter physics classes with preconceptions in the area of Newton's third law. Brown (1989) indicates "that these preconceptions are persistent and difficult to overcome with traditional instructional techniques. The persistence of preconceptions concerning the third law may result from students' general naive view of force as a property of single objects rather than as a relation between objects (Brown, 1989).

According to Grayson (1995) students have many non-scientific conceptions even after instruction. The author further indicates that some misconceptions arise from instruction itself.

Expert physicists versus beginning students

When helping students to recognize how concepts they learn can be applied, "we must find ways of assuring that they also recognize that the conceptual world that is taking shape is congruent to, and must be cross-referenced with, the world of experience (Touger *et al.*, 1995)." Touger *et al.* (1995) indicate that experts assess one another by producing clear explanations, but beginning students tend to be poor explainers. In Physics I students are rarely asked to give qualitative explanations. It is however not surprising that 'novice students' explanations on how to solve problems are usually equation-centred and disorganized (Touger *et al.*, 1995).

2.14 Summary

This chapter gave a brief outline of the Government Policy on mathematics and physical science, and the state of physics in South Africa. Enough literature indicates that students' performance in mathematics and physical science in South Africa is in a bad state and the Government is concerned. The employers of physics graduates and

job opportunities in physics were discussed. It is indicated that outside teaching, there are very few job advertisements for physicists. This chapter also discussed students' performance and students' attitudes and beliefs. The literature indicates that students' interest in science affects their motivation.

Factors such as language, rural and urban schools are also reported to influence students' performance in physical science. Different foundation programmes of some of the South African universities were discussed. Teaching and learning strategies and conceptual understanding were also explored.

Chapter 3

Research Process and Methods

3.1 Introduction

This chapter discusses the research process and methods used in the study. It also outlines the study area, participants, instruments used, data collection and data analysis techniques.

3.2 Study Design

This study explores the effect of Foundation Physics (with particular focus on mechanics) on students' performance in Physics I at several South African universities. This is a piece of evaluation research, where the evaluation object is the Foundation Physics course. An evaluation object is that which is being evaluated (Guba & Lincoln, 1981; Scriven, 1967; Worthen, Sanders, & Fitzpatrick, 1997). Evaluation involves determining the worth, merit, or quality of an evaluation object (Johnson & Christensen, 2000).

3.3 Study Area

Since the focus of the study is to investigate the influence of Foundation Physics on students' performance in Physics I, students from four South African universities were considered. Several other universities were approached to participate, but were not available. Thus the universities selected represent a convenience sample comprising universities that were within a 4-hour drive of the researcher's place of work and that were willing to participate.

All four universities offer Foundation Physics to students who, on the basis of their Grade 12 performance, failed to meet the entry requirements for Physics I. The four institutions are all classified as Historically Black Universities because they were meant to serve black students who are also known to be historically disadvantaged.

The Foundation Programmes are meant to assist disadvantaged students regardless of race so that they can gain entry into the mainstream courses.

3.4 Participants

Convenience sampling is used in this study because it enables one to study the “sampling units that are conveniently available to the researcher” (Chadwick et al., 1984:65). In this study, students who were readily available on the day of data collection were considered participants. The participants in this research were Physics I students (N = 194) selected from the four institutions: Institution 1 (N = 92), Institution 2 (N = 47), Institution 3 (N = 48) and Institution 4 (N = 7). This group of students includes students who first enrolled for Foundation Physics (N=72) and those who qualified to do Physics I (N=122) on the basis of their Grade 12 symbols. Students who did not obtain good symbols in Grade 12 and they want to do a qualification that requires Physics I enrol for Foundation Physics. After they have passed they will then be able to enrol for Physics I (Introductory Physics). A questionnaire that allowed students to fill in their biographical details including whether or not they did Foundation Physics, was attached to the FMCE answer sheet. The students were all registered for Physics I in 2004, and by the time the research was conducted they had all finished the Mechanics module, the module on which this study is focused.

All 194 students participated in answering the FMCE questionnaire. This represents the number of students who agreed to participate and not the entire student body in the course. The Foundation group and the non-Foundation group from each institution answered the FMCE questionnaire at the same allocated time. Out of 194 students who participated, 26 (12 Foundation group and 14 non-Foundation) were interviewed in focus group interviews. Two focus groups were selected from each institution, i.e. from the Foundation group and the non-Foundation group. Institution 4 had one student representing the Foundation focus group and three students in the non-Foundation focus group. Institution 1 had four students in the Foundation focus group and five students in the non-Foundation focus group. Institution 2 had two students in the non-Foundation focus group and three in the Foundation focus group. Institution 3 had four students from the Foundation focus group and four students from the non-

Foundation focus group. In order to gain more insight into the issues affecting students' performance in Physics I, four Foundation Physics lecturers, one from each of the four institutions, were also interviewed. The procedure for choosing interview volunteers will be discussed later.

3.5 Instruments and data sources

For the purpose of triangulation, qualitative and quantitative styles of research and data collection were used (Chadwick et al. 1984:40 & Neuman, 2000:125). According to McMillan and Schumacher (2001:41), qualitative techniques involve data collection in the form of words rather than numbers. Qualitative techniques provide verbal descriptions to portray the richness and complexity of events that occur in natural settings from the participants' perspectives. Once collected, the data are analyzed inductively to generate findings.

Quantitative research techniques emphasize a priori categories to collect data in the form of numbers (Johnson & Christensen, 2000:17; McMillan & Schumacher, 2001:40). The goal is to provide statistical descriptions, relationships, and explanations (Johnson & Christensen, 2000:17; McMillan & Schumacher, 2001:40). In order to exploit the richness of the possible research findings, both qualitative and quantitative approaches are used in this study. In this study, Force and Motion Conceptual Evaluation (FMCE) test and mechanics marks derived from exam and tests were used to compare students' performance in physics. Although the two instruments are used to assess understanding of mechanics, they differ because FMCE is a standardised test that measures students' conceptual understanding and mechanics tests and exams evaluate the understanding using mostly questions that require students to calculate and/ or derive (see Appendix E). The exam question papers differ from one institution to another, however because of similar style of questions asked they are all regarded as uniform and hence used in this study.

FMCE questionnaire

The FMCE test (see Appendix C), like most other survey methods, is a paper and pencil test (McMillan & Schumacher, 2001:40) that "permits the collection of data from large numbers of respondents in relatively short periods and at relatively low

costs” (Chadwick *et al.*, 1984:100). The resulting test scores are used as data (McMillan & Schumacher, 2001:40). The FMCE is a multiple choice 48-question standardized test which was developed to evaluate student learning in introductory physics (Thornton & Sokoloff, 1998). A copy of this instrument was received from David R. Sokoloff in 2004. FMCE has been used to evaluate large numbers of students at many colleges, universities, and high schools mostly in the USA. Thornton and Sokoloff (1998) did an extensive controlled testing at the University of Oregon and Tufts University.

Amongst other questions from the FMCE that probe students’ views of force and motion concepts are the “Force Sled” questions (questions 1-7), the “Cart on Ramp” questions (questions 8-10), the “Coin Toss” questions (questions 11-13), and the “Force Graph” questions (questions 14-21) (Thornton & Sokoloff, 1998). The FMCE is very useful when comparisons among student answers on different set of questions are examined. This study also compares the performance of two groups of students in Physics I, i.e. those students who came through Foundation Physics (Foundation group) to those who gained straight entrance grades from Grade 12 (non-Foundation group). The understanding of force concepts is measured only after the students have been taught the mechanics module. Thornton and Sokoloff (1998) found that most students answered the Coin Toss questions and the Cart on Ramp questions in a non-Newtonian way even after they had answered most of the other questions on the FMCE in a Newtonian manner.

The study of conceptual understanding using FMCE conducted mainly in the USA showed “that introductory physics students do not commonly understand kinematics and dynamics concepts as a result of thorough traditional instruction” (Thornton & Sokoloff, 1998). However this thesis seeks to evaluate this instrument in a South African context by looking at the differences in performance among Foundation and non-Foundation groups of students. Students from the Universities of Oregon and Tufts were tested on FMCE before and after Active Learning Laboratories (Thornton & Sokoloff, 1998). Thornton and Sokoloff (1998) indicate that the students performed poorly before Active Learning Laboratories.

Interviews

Both interviews in this study are semi-structured and open ended. The student interview protocol (Appendix A) used in this research was adapted from Moore et al (2004). The interview protocol is open-ended, allowing the respondents the freedom of expressing themselves. In contrast to most surveys, open-ended interview protocols are designed to allow the respondent to speak freely about their experiences without being limited by predetermined response categories. Follow-up questions to get more insight into the respondent's experiences are not prohibited.

The student interview protocol consists of questions about the respondents' backgrounds, the Physics I course, how students experience the lecture, practicals, tutorials, topic-oriented approach, expectations, attitudes towards physics, skills acquired in class and laboratory, understanding of concepts, confidence, coping with the workload, role of tutors, lecturers and other students, general questions, and how Foundation Physics helped the Foundation group to cope with Physics I.

The Foundation Physics lecturer interview protocol (Appendix B) is comprised of 11 questions under the categories: the structure of the course, course content, relationship between Foundation Physics and Physics I, and some conceptual questions. The Foundation Physics lecturer interview gives more information on some of the issues that were not clarified by students in their respective focus groups.

Mechanics marks

The mark sheets were collected from the relevant mechanics lecturers with the permission of the Heads of Departments. The Physics I mechanics final examinations papers appear in Appendix E. Institution 1 failed to give the researcher its examination question paper. The types of questions asked at each institution are indicated in Table 3.1 below. These marks indicated the performance of students in the mechanics module. The purpose of these marks is to compare them with the performance of students in the FMCE test. Institution 1's question paper consisted of questions asking students to derive and calculate. There are no questions that ask students about their conceptual understanding. Institution 4's question paper also lacked conceptual questions. However there was a good representation of multiple choice questions that would have prepared the students for the FMCE test. Although

Institution 3's question paper lacked multiple choice questions, all the other categories were fully represented.

Table 3.1: The number (percentage mark given in parentheses) of questions asked in Physics I mechanics final examination for each institution

Type of Question	Institution 2	Institution 3	Institution 4
Derivations	4 (41)	2 (11)	2 (16)
Calculations	5 (59)	11 (63)	6 (45)
Multiple choice			11 (34)
Define or State		4 (6)	1 (5)
Conceptual or Discussion		4 (20)	
Total mark	(100)	(100)	(100)

The exam papers were analyzed to determine the percentage mark that covers sections covered in the FMCE. As can be seen in Table 3.2, question papers from Institutions 3 and 4 covered enough sections of the FMCE with percentage marks of 26% and 36% respectively. Although 26% of Institution 2's question paper covered sections of the FMCE, the questions were only looking at the concept of acceleration. All the three institutions did not ask questions in kinematics graphs, a section which carries 45% in the FMCE test. Since the institutions' question papers cover a small percentage of sections covered by FMCE test, it is evident that the students will not perform well in this test.

Table 3.2: The percentage mark of the exam question paper that covers content area similar to that covered by the FMCE for each institution (the percentages are rounded)

	Institution 2	Institution 3	Institution 4	FMCE
Newton's first and second laws	0	3	16	15
Gravity (force and / or acceleration)	0	10	9	13
Kinematics graphs	0	0	0	45
Newton's third law	0	1	3	21
Inclined plane	0	3	0	2
Acceleration	26	9	6	
Total percentage	26	26	36	96

Foundation Physics student guides

The Foundation Physics student guides serve the purpose of informing the students about the rules and regulations to be followed in the course/programme and mark allocation for each subsection. They also indicate which sections are covered in the course. The guides were requested from the relevant lecturers of Foundation Physics from the four universities. Only two institutions submitted their Foundation Physics guides. However, more information about the syllabus of Foundation Physics was collected during the Foundation Physics lecturer interviews. Amongst other things indicated in the guides are the aims and objectives that students are expected to achieve at the end of the course. These aims and objectives inform the researcher about the development of those students who were enrolled for Foundation Physics before registering for Physics I.

3.6 Data collection methods

Data were collected using qualitative methods in the form of tape-recorded students' focus group interviews, and tape-recorded individual Foundation Physics lecturer face-to-face interviews. Quantitative methods that include a standardized mechanics (FMCE) questionnaire, and mechanics mark were also used. Data about the classification of schools from which the students matriculated was collected from the Department of Education. The researcher was directly involved throughout the data collection process.

FMCE standardized test

A pilot study of the standardized FMCE questionnaire was conducted with students who passed Physics I in 2003. These students had just started with their second year of Physics major. The aim of the pilot study was to determine the estimated amount of time that the students would take to answer the questionnaire and the extent of the questionnaire difficulty. Attached to the FMCE answer sheet was the biographical information questionnaire which students filled in before answering the FMCE. The FMCE questionnaire was then distributed to the Physics I classes of the four universities, one after the other in 2004. The researcher personally handed out the questionnaires and explained the procedure that the students should follow when answering the questions. The instrument was only used as post-test and not as pre-test in order to void logistical problems. It was difficult to get students to write the FMCE

test and it would have been more difficult to gain access to them twice (for a pre-test and a post-test).

All the Physics Departments were asked beforehand to inform their students about the test. Each department was expected to get a 100% student turn-out. However, due to some miscommunication between the Physics Departments and their respective Physics I students, a 100% turn-out was not achieved. From each Physics Department more than 50% of Physics I students were present for the test. The absence of the other students might not have caused difference in the final results of this study. However, it should be borne in mind that this is just a conjecture since the researcher does not have enough information to know for sure. The figures of students who wrote the test were 92 from Institution 1, 47 from Institution 2, 48 from Institution 3, and 7 from Institution 4. These figures include students who underwent Foundation Physics.

Mechanics exams

The students' mechanics final marks were requested from the relevant departments. An average mechanics mark was made up of assignment, test and final examination marks. Assignments and tests contributed to the year mark or semester mark. The aggregate mechanics mark was comprised of year mark and final examination mark. Table 3.3 below indicates the proportions of semester/ year mark and final examination mark for each institution. The proportions are the same in three institutions putting more emphasis on the year/ semester mark. The tests and assignments differed from department to department. These marks were acquired from the relevant lecturers with the permission of the Heads of Departments together with their respective Deans.

Student focus group interviews

In the case of student interviews, the staff members tasked by the Heads of Departments were requested by the researcher to assemble two groups of students that were chosen according to their performance in the FMCE questionnaire, and gender. Students who came to Physics I through Foundation Physics formed one group called

the Foundation group, and those who were not part of the Foundation Physics formed a different group called the non-Foundation group. The focus groups comprised two students (male and female) who scored the highest marks in the FMCE test and two students (male and female) who scored lowest.

Table 3.3: Proportions of mechanics mark for each institution (the proportions for Institution 1 were found from the institution's website and the other proportions for Institutions 2, 3, and 4 were found from the relevant lecturers)

Institution	Percentage of year/ semester mark	Percentage of final examination
Institution 1	50	50
Institution 2	60	40
Institution 3	60	40
Institution 4	60	40

The envisaged number of students in each focus group was four. However five students from Institution 1 were selected for the non-Foundation group because in this institution there were three students who did exceptionally well in the FMCE test. Two of these students were males and the other two were females. The Foundation group from Institution 3 had only one female student. The 26 students interviewed from the four institutions were grouped as follows: Institution 1 non-Foundation group (5), Institution 1 Foundation group (4), Institution 2 non-Foundation group (2) (a female who scored low and a male who scored highest in the FMCE test), Institution 2 Foundation group (3) (one male student who got the second highest score did not attend), Institution 3 Foundation group (4), Institution 3 non-Foundation group had four (4) students of which two were males and the other two were females. Institution 4 Foundation group had only one male student (this was the only student who did Foundation Physics at Institution 4, and Institution 4 non-Foundation group (3 male students).

Before the interview, the students were informed about the snacks prepared for them, which were then provided to them at the end of the interview. As a token of

appreciation, staff members of the different institutions who were helping were paid a fee of R150.00 through their supervisor at the end of the interview.

Foundation Physics Lecturer interviews

The Foundation Physics lecturers' interview protocol (Appendix B) is designed in line with the students' interview protocol and the FMCE. Its aim is to triangulate information about Foundation Physics obtained from the students' interviews as well as to help explain students' performance in the FMCE. Four lecturers from the four universities took part in the interviews. Each of the interviews took between 30 and 40 minutes.

3.7 Ethical issues

Letters asking for permission to conduct research in different Physics departments were directed to the Deans of the Faculties of Science at six South African universities offering Foundation Physics. From the six universities, only four responded positively. As is usually the procedure with most institutions, the Deans of the faculties then directed the researcher to the relevant Heads of Departments who then referred the researcher to the staff members (lecturers and demonstrators) responsible for Physics I students. It was agreed that the information gathered in the research process would not in any way be used to disadvantage the relevant departments and their universities. In other universities binding documents to protect the departments and the universities were signed. Before each research session, students and staff were assured that their names would not be used when presenting the results of the research anywhere.

3.8 Practical issues arising during the fieldwork

The researcher encountered a number of problems pertaining to the delay of responses from the Deans of Faculties of Science. The procedures (ethics) that are followed in different universities delayed the data collection by almost seven months. In some cases, permission to do research in the Departments of Physics was not granted. However, one needs to be thankful to be afforded the opportunity to collect data in the four universities.

3.9 Data analysis

Quantitative data was analyzed using the statistical program, SPSS. χ^2 values are reported. Pearson's Chi-Square values and "Asymp. Sig. (2-sided)" values are provided. The null hypothesis is rejected when χ^2 value is large or "Asymp. Sig. (2-sided)" value is smaller than 0.05, i.e, the null hypothesis is rejected at the 5% level of significance, and conclusion that there exists a relationship between the two variables under consideration is taken. Qualitative data was analyzed using qualitative methods that include coding for the interviews.

Quantitative data

The sources of quantitative data are the students' biographical information (Appendix D); the FMCE questionnaire (Appendix C); mechanics tests and mechanics module results.

Biographical Information (Appendix D)

The researcher collected all the biographical information data from the questionnaire (Appendix D) that each student filled in. The data including the student's name were then given specific numbers so that SPSS can easily recognize and manipulate them since the program identifies numbers and not characters. The numbers representing the students' names were entered in column 1. Since the students were 194 in number, three digit numbers were used. The first student was allocated number 001 and the second student was allocated number 002, until the last student was given number 194. The student's gender appeared in column 2, with 1 used for males and 0 for females. Similarly, all other information relating to the student's biography such as whether the student did Foundation Physics (represented by 1) or not (represented by 0) was categorized in the same fashion.

The FMCE questionnaire (Appendix C)

The 48 questions in the FMCE were each put in different columns. Since the student could have either given a correct answer or a wrong answer, only single digit numbers, 0 and 1, were used to represent their answers for all the 48 questions. For the researcher to be able to compare the students performance in the FMCE, for example, in questions Q1 to Q7 as in Figure 4.14(a), the SPSS was instructed to

categorize students as Foundation and Non-Foundation, and also if they answered those questions correctly (1) or incorrectly. SPSS was instructed to manipulate the information that was fed in and gave the results in terms of numbers and percentage. All other data were manipulated in a similar way.

Qualitative data

The sources of qualitative data are students' interviews (Appendix A) and Foundation Physics lecturers' interviews (Appendix B).

Students' interviews (Appendix A)

The researcher listened to each of the recorded interviews from the four institutions. The interviews were transcribed by means of listening and typing word for word using a computer. The student voices were memorised and associated with a number representing that particular student. In order to prevent associating the student's voice to another student, the transcription of one group was done continuously without interruption. The transcribed information was later transferred onto A4 pages by printing. Each of the transcribed interviews was labelled, for example Institution 1 (Foundation) and Institution 1 (non-Foundation) representing the institution and the group of students interviewed. Institution 1 (Foundation) represents Foundation group of students from Institution 1 and Institution 1 (non-Foundation) represents a non-Foundation group of students from Institution 1. All the other groups of students were labelled the same way. Each of transcribed interviews was given subheadings that related to the main questions asked during the interview. Since similar questions were asked for all the groups, all the transcribed interviews had the same outline or items. Students that were interviewed were identified as S1, S2, etc, with S standing for student and a number 1, or 2, etc. representing student number. The interviewer was represented as I. The transcribed Foundation group interviews were grouped together. Similarly, the non-Foundation transcribed interviews were also grouped together. The two groups of transcribed interviews were then compared item by item against themselves (Foundation group against Foundation group and non-Foundation group against non-Foundation group) and against different groups to check the differences and similarities in the responses. Similarities and differences that were identified are reported in Chapter 5.

Foundation Physics lecturers' interviews (Appendix B)

The researcher listened to the recorded lecturers' interviews one after the other and the information was typed using a computer. The information was later printed on A4 pages to make it easy for the researcher to compare. The main questions that were raised during the interview appeared as items to be used for comparison. The lecturers were identified as L1, L2, L3, and L4. The letter L stands for lecturer and the numbers indicate the institution at which they were based. The interviewer was labelled as I. The lecturers' responses were compared amongst each other and also against students' responses and the results are also indicated in Chapter 5.

Chapter 4

Mechanics Tests and Course Results

4.1. Introduction

This chapter presents the findings of the data collected through the use of both the questionnaire and focus group discussions. The chapter is divided into two main sections, namely, respondent demographics and students' performance. The section on respondent demographics presents respondents' characteristics, including among others, the number of sampled respondents per university, year of matriculation, number of students who did Foundation Physics and those who did not do Foundation Physics, and whether the school attended is rural or urban. The section on respondent performance presents a comparison of Foundation and non-Foundation students' performance in the Mechanics section of Physics I consisting of marks from practicals, tests, assignments and the final examination, and the Force and Motion Conceptual Evaluation (FMCE) questionnaire. Information about the schools was obtained from the Education Management Information System (EMIS) at the National Department of Education.

The topics covered for Foundation Physics and Physics I courses in the institutions considered for this study are indicated in Tables 4.1 and 4.2 below respectively.

Table 4.1 Foundation Physics curricula for different institutions (this information was supplied to the researcher telephonically by staff members from the respective institutions)

Institution	Sections covered in Physics	Topics covered in Mechanics module	Time spent teaching mechanics
Institution 1	Mechanics, Kinetic theory of matter, and Electricity and magnetism	Units and measurements, Vectors, Kinematics of motion, Newton's law of motion, Equilibrium of rigid bodies, Momentum, and Work and energy	16 weeks, 5 periods per week, 60 hours
Institution 2	Mechanics, Heat, Optics and Electricity.	Units and Measurements, Force and motion, Energy and its conservation, Momentum and its conservation	12 weeks, 5 periods per week, 48 hours
Institution 3	Measurement, Energy and temperature, Mechanics, and Electricity	Measurement, Kinematics, and Dynamics	14 weeks, 6 periods per week, 63 hours
Institution 4	Waves and Sound; Mechanics; Optics; Modern Physics; Electricity and Magnetism; Physics Practicals; and Properties of Matter and Thermodynamics	Force and motion; energy and its conservation; momentum; and gravity	15 weeks, 3 periods per week, 33 hours 45 minutes

Table 4.2 Physics I curricula for different institutions (this information was supplied to the researcher telephonically by staff members from the respective institutions)

Institution	Sections covered	Topics covered in mechanics module	Time spent Teaching mechanics
Institution 1	Mechanics; Oscillations and Heat; Introduction to Biophysics; Physics Practicals; Introduction to Electricity and Magnetism; and Optics and Introduction to Modern Physics	Motion of particle in one-dimension; vectors; circular motion; force; Newton's laws; gravitation; work and energy; elastic and inelastic collisions	8 weeks, 4 periods per week, 27 hours
Institution 2	Mechanics; Waves and Optics; Physics Practicals; Properties of Matter and Thermal Physics; and Electricity and Magnetism	Motion in 1D, Vectors, Motion in 2D, Newton's laws of motion and their applications, circular motion, Work and energy, Linear momentum and collisions	12 weeks, 3 periods per week, 24 hours
Institution 3	Optics, Waves and Sound; Mechanics; Geometrical Optics; Modern Physics; Electricity and Magnetism; Physics Practicals; and Properties of Matter and Thermodynamics	Measurement and vectors; linear motion; planar motion; Newton's laws and applications; forces and equilibrium; work, energy and power	12 weeks, 4 periods per week, 36 hours
Institution 4	Optics, Waves and Sound; Mechanics; Geometrical Optics; Modern Physics; Electricity and Magnetism; Physics Practicals; and Properties of Matter and Thermodynamics	Measurement and vectors; linear motion; planar motion; Newton's laws and applications; forces and equilibrium; work, energy and power	14 weeks, 3 classes per week, 30 hours

All institutions but Institution 4, offer Foundation Physics consisting of four sections. However all Foundation Physics courses from the four institutions offer Mechanics and Electricity. Foundation Physics in all the institutions indicated in Table 4.1 offer the similar topics in mechanics. However, the amount of time spent teaching the

Mechanics module differs from institution to institution, with Institution 3 spending the most time followed by Institution 1.

The number of modules offered by Foundation Physics at Institution 4 is the same as those in their Physics I (see Tables 4.1 and 4.2 above). However, the number of sections covered in Foundation Physics mechanics is less than those offered in Physics I at the same institution. Amongst the sections offered in Foundation Physics mechanics is gravity which is not covered under Physics I mechanics. On the other hand Physics I mechanics at the same institution covers forces and equilibrium a section not covered in Foundation Physics mechanics. The time spent teaching Foundation Physics mechanics at Institution 4 is more than the time spent teaching Physics I.

At Institution 1, the sections covered in Foundation Physics are less than those offered in their Physics I. The number of sections covered in both Foundation and Physics I mechanics is comparable except that Physics I offers circular motion, whereas Foundation Physics offers equilibrium of rigid bodies. However Foundation Physics mechanics is allocated more than double the amount of teaching time allocated to Physics I.

A similar trend is witnessed at Institution 3 where the number of sections covered in Foundation Physics is less than that covered in Physics I. Also, the number of sections covered in Foundation Physics mechanics is less than in Physics I. The extra sections covered by Physics I mechanics are forces and equilibrium; work, energy and power. As in the case of Institution 1, the time allocated to teaching Foundation Physics mechanics is more than that allocated to teaching Physics I mechanics.

Institution 2 offers few sections in Foundation Physics compared to Physics I sections. They also offer fewer sections in Foundation Physics mechanics compared to sections offered in their Physics I mechanics. The extra section covered by Physics I is circular motion. The teaching time allocated for teaching Foundation Physics is double the amount of time allocated for teaching Physics I mechanics. In all four institutions the amount of time allocated for teaching Foundation Physics is more than that allocated for teaching Physics I mechanics.

4.2. Respondent demographics

The sample used in this study consisted of a total of 194 students. The greatest number of students came from Institution 1 (47.40%), followed by Institution 3 and Institution 2 having 25.30% and 23.70% of students, respectively (Table 4.3 and Figure 4.1). 37.11% (72) of the total number of students took Foundation Physics. Institution 4 had the least number of students (3.60%). A convenience sample was used, i.e. all the available students who were willing to participate were considered for this study. The student Physics I population differs for different universities. Data was treated as a whole so that generalisation could be made, otherwise the institutions would be discussed separately.

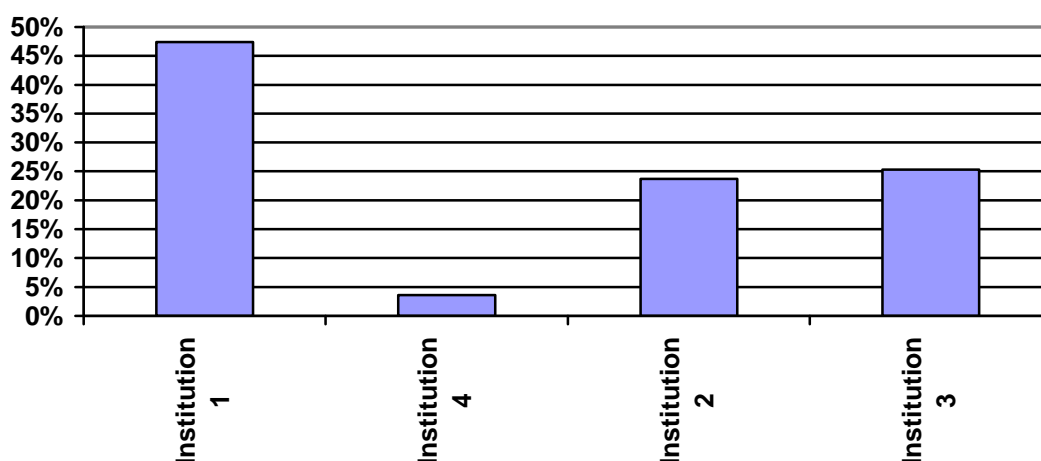


Figure 4.1: Sampled universities (N=4) and the percentage number of students (N=194) at each institution

Table 4.3: Percentage (number in parentheses) of students at each institution

Institution 1	Institution 4	Institution 2	Institution 3
47.4 (92)	3.6 (7)	23.7 (46)	25.3 (49)

Gender

Figure 4.2 and Table 4.4 indicate the gender percentages (N=194) for each institution. The male students outnumber female students in each of the four universities. Of the total number of students (N=194) who participated, 126 (64.40%) were males and 68

(35.60%) were females. It is interesting to note that the percentages of female students at Institutions 3 and 4 are much lower than at the two other institutions.

Figure 4.2: Percentage of students at each institution by gender (N=194)

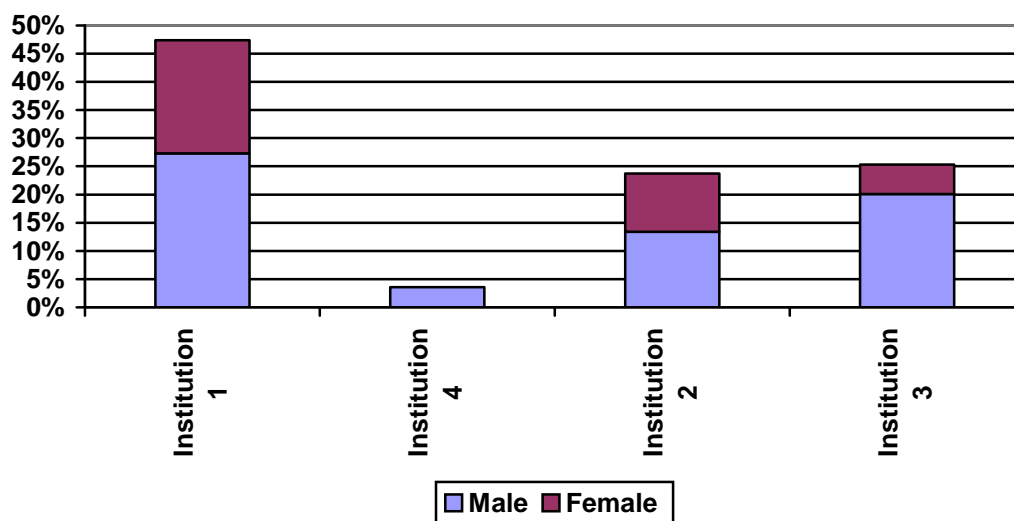


Table 4.4: Percentage (number in parentheses) of students at each institution by gender (N=194)

	Institution 1	Institution 4	Institution 2	Institution 3
Female	20.10 (39)		10.30 (20)	5.20 (9)
Male	27.30 (53)	3.60 (7)	13.40 (26)	20.10 (40)

Age

Figure 4.3 and Table 4.5 show that 61.2% (119) of the students fall in the age category of 20 years and younger, closely followed by students aged from 21 to 25 years in all four universities numbering 34.1% (66). The student population is younger overall at Institution 3 than at the other institutions, indicating that a higher proportion of first year physics students have recently completed their matric than at the other institutions.

Figure 4.3: Percentage of students by age for each institution (N=194)

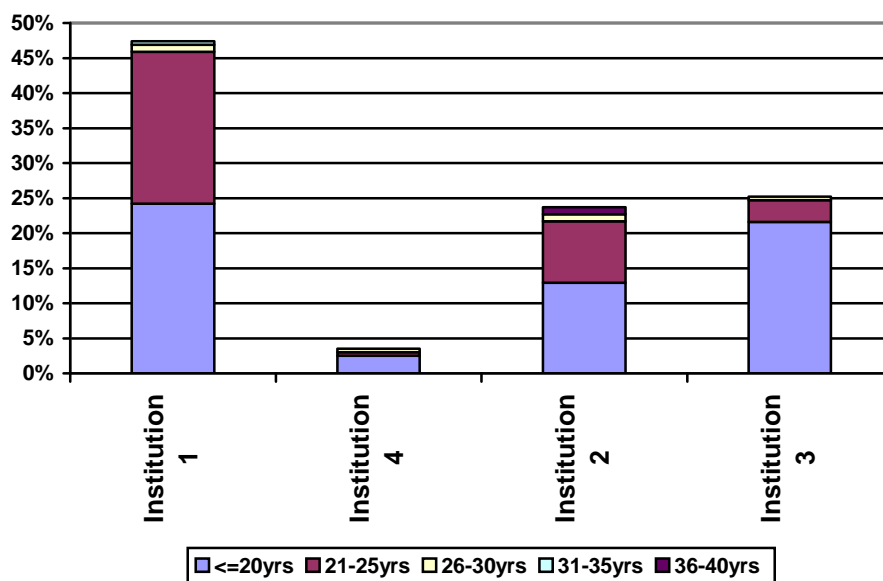


Table 4.5: Percentage (number in parentheses) of students by age for each institution (N=194)

Age (years)	Institution 1	Institution 4	Institution 2	Institution 3
36-40	-	-	1.00 (2)	-
31-35	0.50 (1)	-	-	-
26-30	1.00 (2)	0.50 (1)	1.00 (2)	0.50 (1)
21-25	21.70 (42)	0.50 (1)	8.80 (17)	3.10 (6)
<=20	24.20 (47)	2.50 (5)	12.90 (25)	21.60 (42)

The ages of the students who underwent the foundation courses ranges from ≤ 20 yrs 11.1%; 21-25 yrs 84.7%; 26-30 yrs 2.8% and 31-35 yrs 1.4% (N=72). These numbers indicate that more than half of the foundation students either did matric more than a year before enrolling for a foundation programme (see Table 4.7), or else were repeating Physics I or did not take Physics I during their year of mainstream studies.

Nationality

Figure 4.4 shows that 95% of students who participated in this study are South Africans and the rest are from Botswana (3%); Zimbabwe (1%); and Ghana (1%) with most foreign students (4%) found at Institution 1 (N=194).

Figure 4.4: Country of matriculation (N=194)

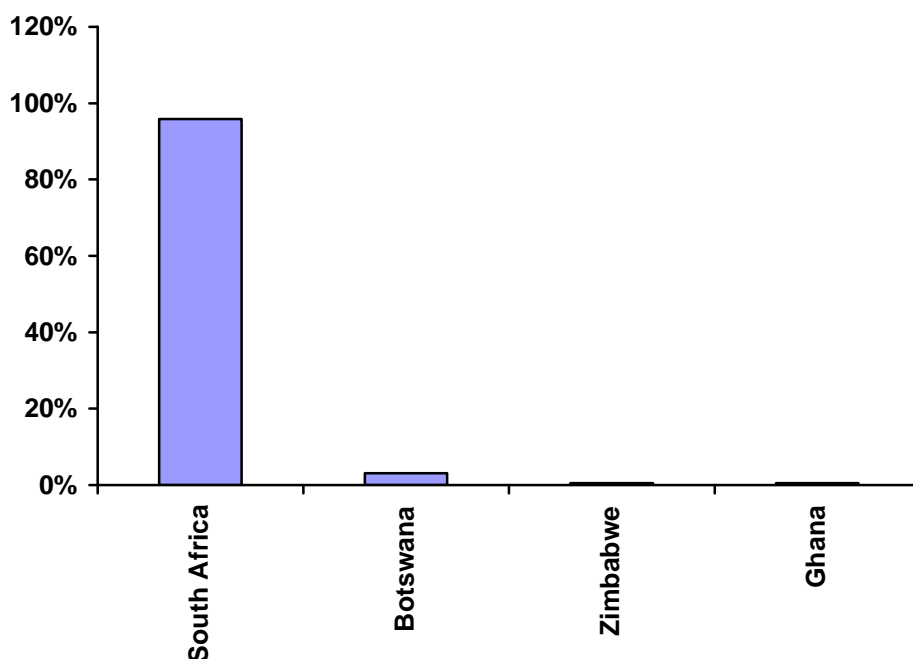


Table 4.6 shows that 61.9% of students are South African males and 34% females; Botswana had 2.1% males and 1% females; Zimbabwe had 0.5% males and Ghana had 0.5% males.

Table 4.6: Percentage (number in parentheses) student gender by country of residence (N=194)

Gender	South Africa	Botswana	Zimbabwe	Ghana
Male	61.9 (120)	2.1 (4)	0.5 (1)	0.5 (1)
Female	34.0 (66)	1.0 (2)		

Year of matriculation

Figure 4.5 and Table 4.7 show that a large number (162) of students passed Grade 12 in the years 2001 (14.7%); 2002 (28.8%) and 2003 (39.8%), with those who passed Grade 12 in 2003 not enrolling for Foundation Physics in 2004. Table 4.7 further shows that most Foundation group students (17.7%) passed Grade 12 examinations in 2002 and a large number of non-Foundation students (39.8%) passed Grade 12 examinations in 2003.

Figure 4.5: Year of matriculation (N=194)

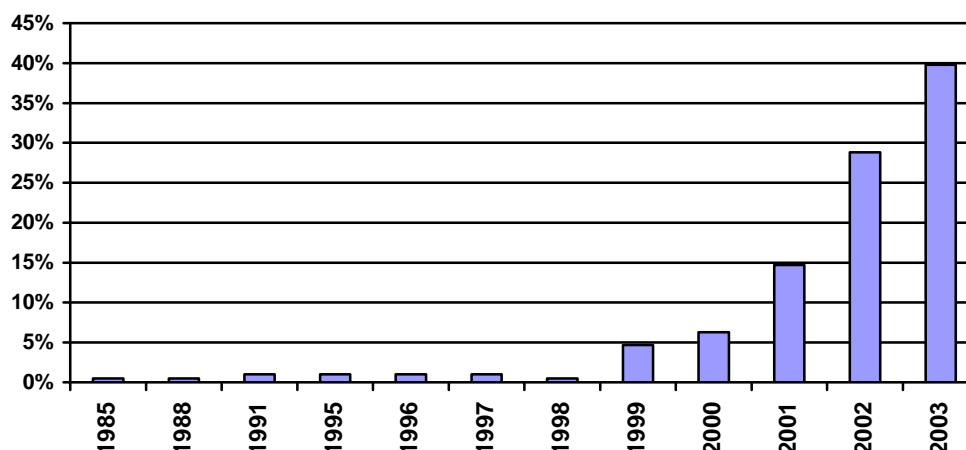


Table 4.7: Percentage (number in parentheses) of students and the year in which they matriculated for Foundation group and the non-Foundation group (N=194)

	1985	1988	1991	1995	1996	1997	1998	1999	2000	2001	2002	2003
Foundation	-	-	0.5 (1)	0.5 (1)	0.5 (1)	1.0 (2)	0.5 (1)	2.1 (4)	4.7 (9)	9.9 (19)	17.7 (34)	-
Non-Foundation	0.5 (1)	0.5 (1)	0.5 (1)	0.5 (1)	0.5 (1)	-	-	2.6 (5)	1.6 (3)	4.8 (10)	11.1 (22)	39.8 (77)
Total	0.5 (1)	0.5 (1)	1.0 (2)	1.0 (2)	1.0 (2)	1.0 (2)	0.5 (1)	4.7 (9)	6.3 (12)	14.7 (29)	28.8 (56)	39.8 (77)

Physical Science symbol

Grade 12 Physical Science symbols (Figure 4.6 and Table 4.8) range from B (HG) to F (HG) and A (SG) to F(SG) for South African students with differing symbols for other countries. HG stands for Higher Grade and it represents a symbol or grade obtained for a subject which is more difficult than the SG (Standard Grade). At Institutions 1, 2, and 3 the minimum required symbol for one to be considered for Physics I is an E(HG) or D(SG) in Grade 12 Physical Science. The required minimum symbol to be considered for Physics I at Institution 4 is a D(HG) or B(SG) Physical Science symbol and an E(HG) or C(SG) to be considered for Foundation Physics. Some students did not indicate the symbols they obtained. The symbols that were not specified are labelled unspecified and this constituted a larger percentage (27%). Although this is a greater percentage, the researcher could still see some differences amongst the specified symbols.

Figure 4.6: Grade 12 Physical Science symbols (N=194)

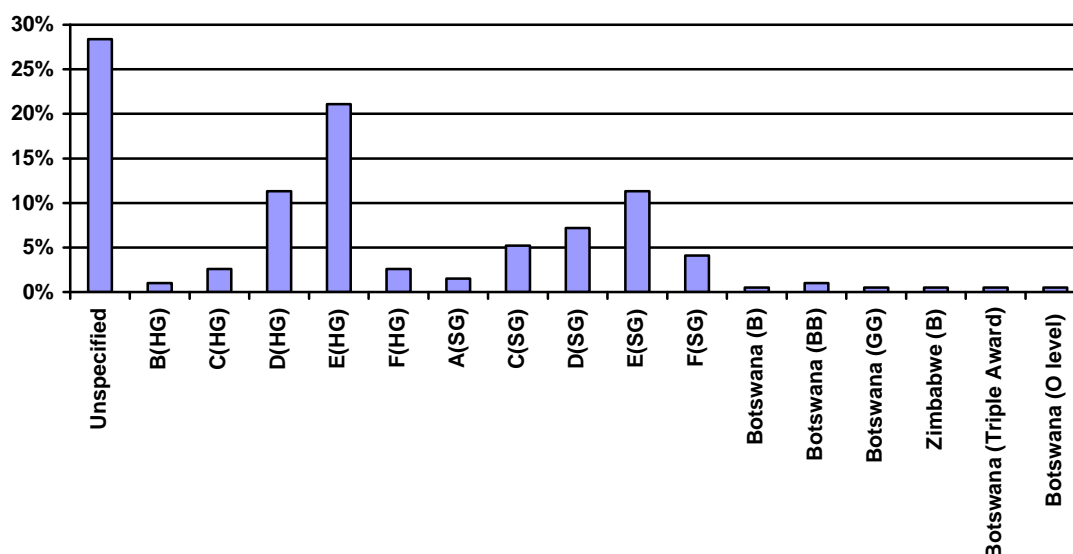


Table 4.8: Percentage (number in parentheses) of students and symbols attained in Grade 12 Physical Science (N=194)

Unsp ecifi ed	B (HG)	C (HG)	D (HG)	E (HG)	F (HG)	A (SG)	C (SG)	D (SG)	E (SG)	F (SG)	B Bots	BB Bots	GG Bots	B Zimb	Tripl Bots	O- Bots
28.4 (55)	1.0 (2)	2.6 (5)	11.3 (22)	21.0 (41)	3.0 (6)	1.5 (3)	5.2 (10)	7.2 (14)	11.3 (21)	4.1 (8)	0.5 (1)	1.0 (2)	0.5 (1)	0.5 (1)	0.5 (1)	0.5 (1)

Foundation Physics

Figure 4.7 and Table 4.9 show most students did Foundation Physics at Institution 1 (54.2%), followed by Institutions 2 and 3 with 30.6% and 8.3% respectively. Some students did Foundation courses at other institutions that are referred to as Other 1, Other 2, Other 3, and other 4 respectively in this study. Those students formed a smaller percentage.

Figure 4.7: Percentage of students and institutions where they took Foundation Physics (N=72)

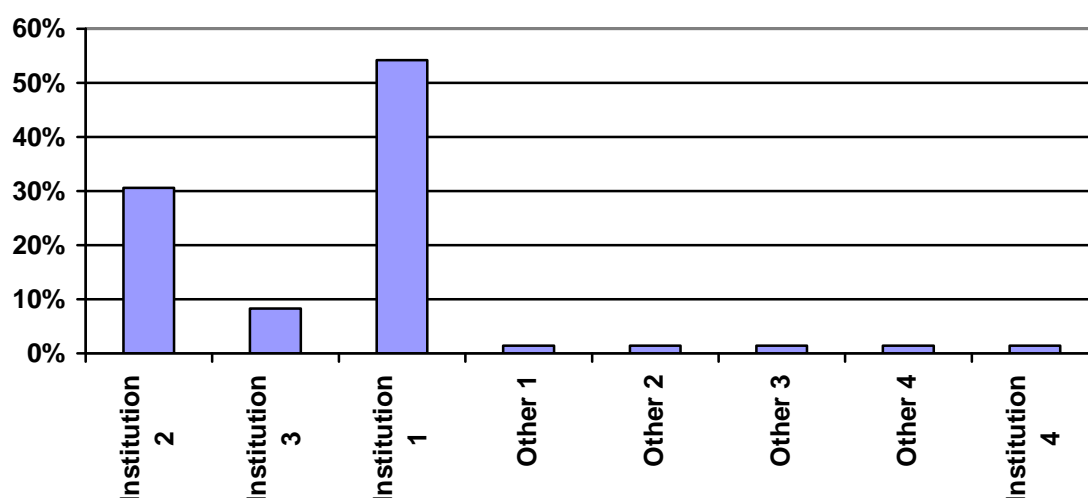


Table 4.9: Percentage (number in parentheses) of Foundation students and institutions from which they took Foundation Physics (N=72)

Institution 2	Institution 3	Institution 1	Other 1	Other 2	Other 3	Other 4	Institution 4
30.6 (22)	8.3 (6)	54.2 (39)	1.4 (1)	1.4 (1)	1.4 (1)	1.4 (1)	1.4 (1)

Province of matriculation

Figure 4.8 and Table 4.10 below indicate that most students considered for this study schooled in the Limpopo Province (37.1%) followed by those who schooled in the North West Province (34.5%). The reason why a large number of students in this study schooled in Limpopo is because two universities from this province were considered for this study.

Figure 4.8: Percentage (number) of students by Province/country of Matriculation (N=194)

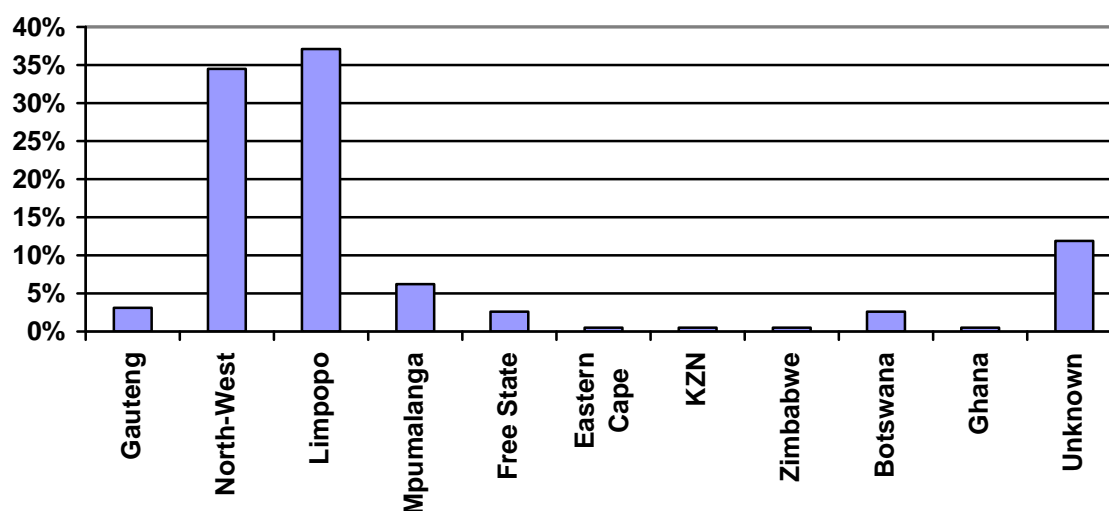


Table 4.10: Percentage (number in parentheses) of students and Province/country of Matriculation (N=194)

Gauteng	North West	Limpopo	Mpumalanga	Free State	Eastern Cape	KZN	Zimbabwe	Botswana	Ghana	Unknown
3.1	34.5	37.1	6.2	2.6	0.5	0.5	0.5	2.6	0.5	11.9
(6)	(67)	(72)	(12)	(5)	(1)	(1)	(1)	(5)	(1)	(23)

Province of residence for Foundation Physics students

Most students who enrolled for Foundation Physics are from the Limpopo Province (12.40%), followed by Northwest Province (9.80%) as shown in Figure 4.9 and Table 4.11 below.

Figure 4.9: Percentage (number) of students for Foundation and non-Foundation groups and the province/country in which they matriculated (N=194)

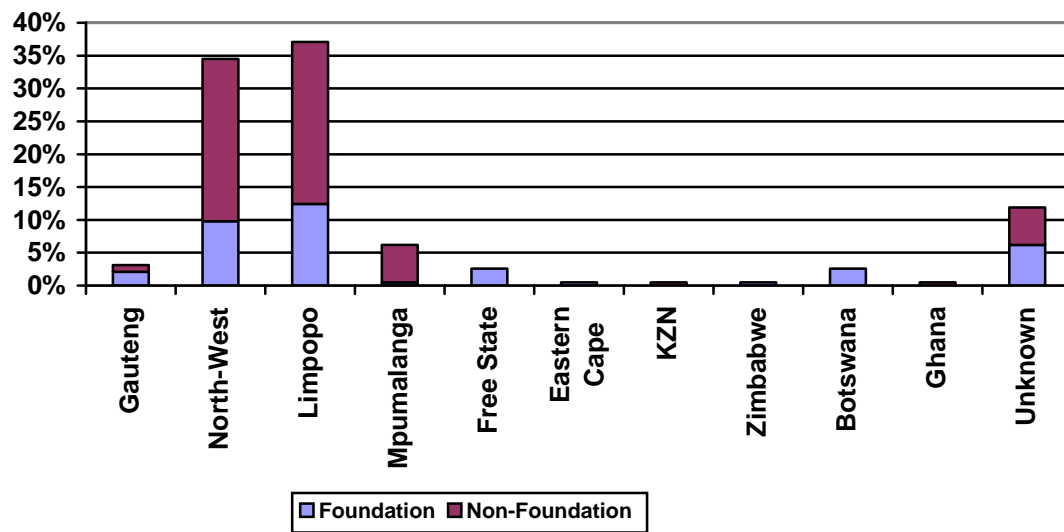


Table 4.11: Percentage (number in parentheses) of students in Foundation and non-Foundation groups and provinces/country in which they matriculated (N=194)

	Gauteng	North West	Limpopo	Mpuma Langa	Free State	Eastern Cape	KZN	Zimbabwe	Botswana	Ghana	Unknown
non-Foundation	1.0 (2)	24.7 (48)	24.7 (48)	5.7 (11)	-	-	0.5 (1)	-	-	0.5 (1)	5.7 (11)
Foundation	2.1 (4)	9.8 (19)	12.4 (24)	0.5 (1)	2.6 (5)	0.5 (1)	-	0.5 (1)	2.6 (5)	-	6.2 (12)

Sector of school where student matriculated

Figure 4.10 shows that 81% of all the students (N=194) attended Government Public schools and only 4% attended Private schools. The other 15% consisted of students for whom their schools were categorized as Unknown.

Figure 4.10: Percentage of the sector of the school in which the student matriculated (N=194)

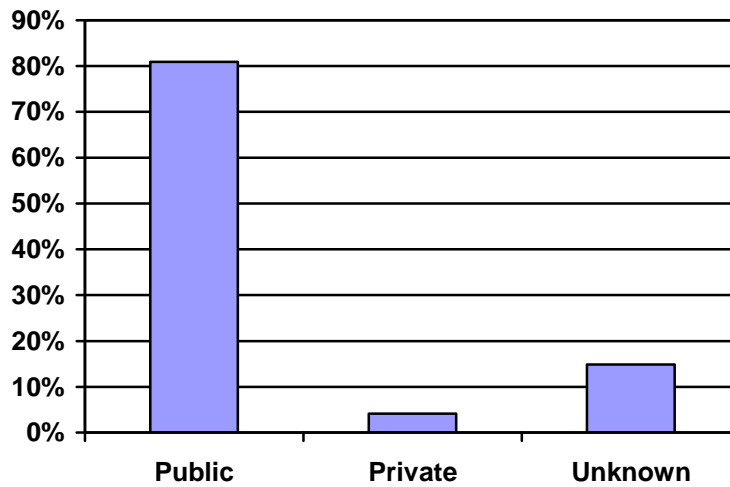


Table 4.12 shows that most of the students who did Foundation Physics matriculated from public schools (26.3%) compared to those coming from private (1.5%) (N=194). However, it is interesting to note that of the 8 students who attended private schools, nearly half (3) attended a foundation programme.

Table 4.12: Sector of school attended (N=194)

		Foundation		Total
		Yes	No	
Sector	Public	Count 51	Count 106	Count 157
		% of 26.3%	% of 54.6%	% of 80.9%
	Private	Count 3	Count 5	Count 8
		% of 1.5%	% of 2.6%	% of 4.1%
	Unkno wn	Count 18	Count 11	Count 29
		% of 9.3%	% of 5.7%	% of 14.9%
Total		Count 72	Count 122	Count 194
		% of 37.1%	% of 62.9%	% of 100.0%

Area where school of matriculation is situated

A large number of students considered for this study (54.60%) (106) matriculated at rural schools as compared to 30.40% from urban schools as indicated in Figure 4.11 and Table 4.13.

Figure 4.11: Percentage of students and the areas where their schools are situated (N=194)

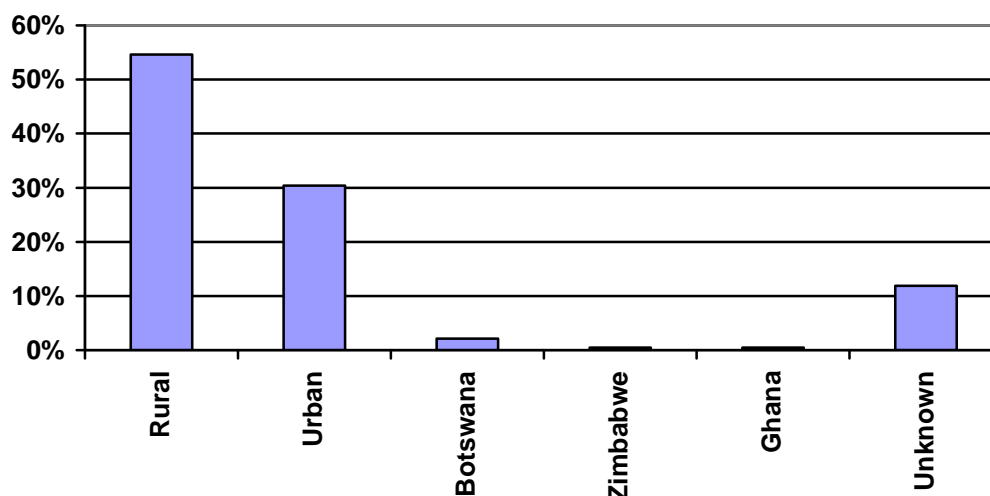


Table 4.13: Percentage (number in parentheses) of students and the areas where their schools are situated (N=194)

Rural	Urban	Botswana	Zimbabwe	Ghana	Unknown
54.6 (106)	30.4 (59)	2.1 (4)	0.5 (1)	0.5 (1)	11.9 (23)

The schools in rural areas are not adequately equipped in most respects, e.g. in physical science, as indicated by one Foundation group student during interviews:

S4: ...but unfortunately we are from very poor, very disadvantaged schools...

The non-Foundation students have similar comments about their poor school background:

S20: Even myself, at our school I didn't touch even a single [equipment], I didn't observe even a practical, you just have a class only, you just know about theory.

S21: ...we didn't have many apparatus to do practicals, in mechanics I think Newton's laws and I didn't know the trolley, then when we came here they started showing us these things...

S24: ...we didn't have enough, ...things to practice in the lab. Then we used much theory, but at least we managed to pass.

S25: ...our school was not having so much facilities in terms of practicals and some of the teaching materials, ...and it's been tough for me in the preparation of my physics for Matric to university one.

The Foundation group students, most of whom attended rural schools, did not do well in the Grade 12 Physical Science examination.

Figure 4.12 and Table 4.14 show that Institution 3 had the largest number of students from rural schools (19.10% of 194 students), followed by Institution 2 (17.50%),

Institution 1 and Institution 4 at 16.50% and 1.50% respectively. Institution1 had the largest number of students from urban schools 22.20%, with the other universities having less than 5% each.

Figure 4.12: Percentage of students and the areas where their schools are situated for each university (N=194)

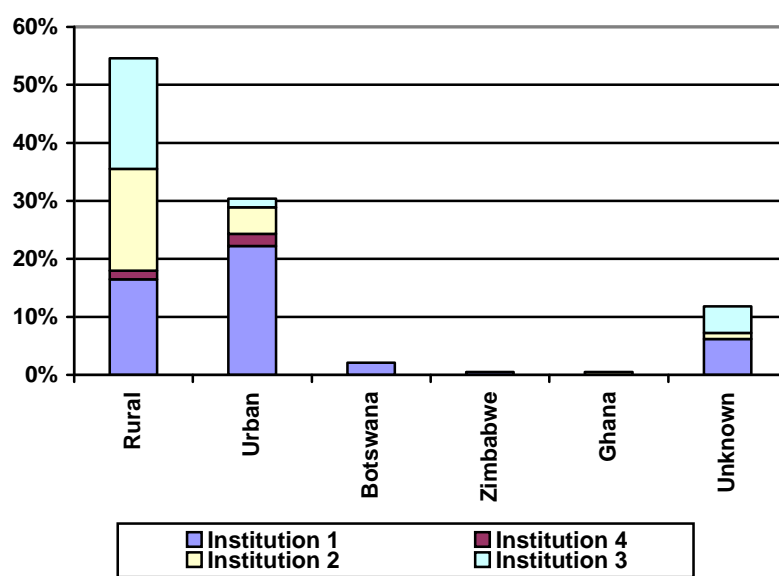


Table 4.14: Percentage (number in parentheses) of students and the areas where their schools are situated for each university

	Rural	Urban	Botswana	Zimbabwe	Ghana	Unknown
Institution 1	16.5 (32)	22.2 (43)	2.1 (4)	0.5 (1)	-	6.2 (12)
Institution 4	1.5 (3)	2.1 (4)	-	-	-	
Institution 2	17.5 (34)	4.6 (9)	-	-	0.5 (1)	1.0 (2)
Institution 3	19.1 (37)	1.5 (3)	-	-	-	4.6 (9)

Figure 4.13 and Table 4.15 show that of the 106 students who matriculated in rural schools 30% (32) did Foundation Physics and 70% (74) qualified to do Physics I. The ratio of rural to urban students is so much higher for non-Foundation than for

Foundation students. This could be indicating that foundation courses are not getting enough publicity to rural students than to urban students.

Figure 4.13: Percentage number of students in the Foundation and the non-Foundation groups against the areas in which their schools are situated (N=194)

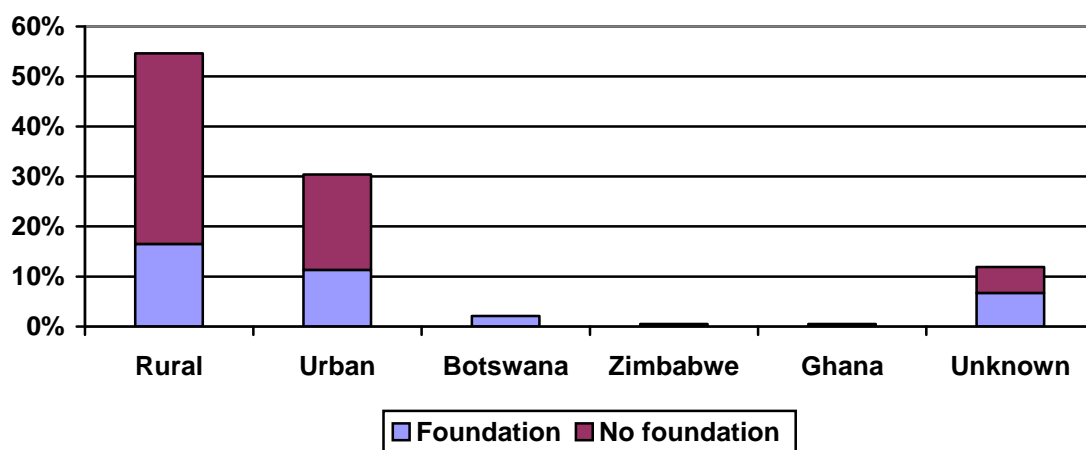


Table 4.15: Percentage (number in parentheses) of students in the Foundation and the non-Foundation groups and the areas in which their schools are situated (N=194)

	Rural	Urban	Botswana	Zimbabwe	Ghana	Unknown
Foundation	16.5 (32)	11.3 (22)	2.1 (4)	0.5 (1)	-	6.7 (13)
Non-Foundation	38.1 (74)	19.1 (37)	-	-	0.5 (1)	5.2 (10)

4.3. Respondent performance

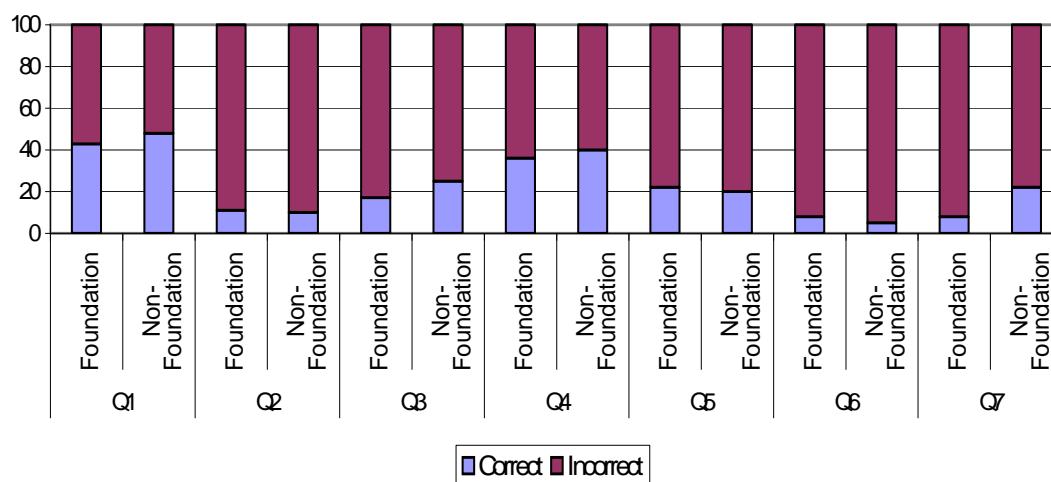
In the results that follow, the FMCE (Force and Motion Conceptual Evaluation) questions have been paraphrased in a table under each graph so that the graphs can be easily interpreted. In this section post-test scores and not the gain were used. The reason for using the post-test scores is to be able to compare Foundation and the non-Foundation groups after they were all taught the same. The study was conducted at the end of the mechanics course. However, the FMCE questionnaire is given in Appendix C and the students' biographical information is given in Appendix D. The statistical software used to analyze the data is SPSS and Chi-Square tests were used to check whether there were statistically significant differences. Pearson's R was used to check correlation among the data.

Foundation and non-Foundation Physics FMCE performance

In the results presented in this section, the questions on the FMCE have been divided into 10 groups, with each group containing questions that relate to the same concept. Results are shown separately for foundation and non-foundation students, and differences in the performance of the two groups of students are tested for statistical significance.

There are statistically significant differences between the Foundation group and non-Foundation group in Force Sled Questions Q1 to Q6, with the former group performing better than the latter. The χ^2 and p values for questions Q1 to Q6 are ($\chi^2 = 0.367$; $p = 0.545$); ($\chi^2 = 0.080$; $p = 0.778$); ($\chi^2 = 1.676$; $p = 0.195$); ($\chi^2 = 0.314$; $p = 0.575$); ($\chi^2 = 0.180$; $p = 0.671$); and ($\chi^2 = 0.910$; $p = 0.340$) respectively. There is no statistically significant difference ($\chi^2 = 0.013$; $p = 0.013$) on Force Sled Question Q7, although both groups of students did poorly on this question. This question, like questions Q1 to Q4, tests Newtonian and non-Newtonian students' views (Thornton & Sokoloff, 1998). The questions are termed "Natural language evaluation" because they measure the understanding of language, "at a steady rate" and Newtonian understanding "(constant acceleration)." It is not clear why there is no statistically significant difference in question Q7 and not in questions Q1 to Q4 since they all measure non-Newtonian and Newtonian student views. The Foundation group performed well in questions Q5 and Q6 as compared to non-Foundation group. Students who have not adopted a Newtonian view answer Force Sled question Q5 by choosing a nonzero applied force. Figure 4.14(a) shows that there is significant difference in the understanding of Newtonian concepts among the two groups, with more Foundation students doing better in question Q5. Question Q6 was originally designed to find out directly whether students believed that the net force is in the direction of acceleration, but research by Thornton and Sokoloff (1998) showed that many students who believed that the resultant force is in the same direction as acceleration chose the "wrong" answer. However, it suffices to say that even though both groups performed poorly on this question more students in the Foundation group got the answer right as compared to the non-Foundation group.

Figure 4.14(a): Percentage students' performance in questions about the force acting on the sled

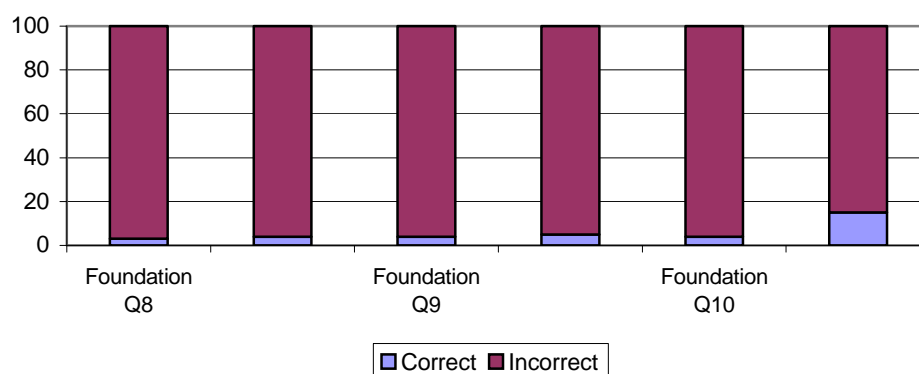


Q1: Which force would keep the sled to the right at constant acceleration,
 Q3: Force to slow the sled down at constant acceleration (steady rate),
 Q5: Force that keeps the sled moving at steady (constant) velocity
 Q7: Force to slow an object moving to the left at steady rate (constant acceleration)

Q2: Force to the right at constant velocity
 Q4: Force to keep the sled moving towards the left at constant acceleration
 Q6: Force that accounts for steady rate and has acceleration to the right

In Figure 4.14(b) below, there are statistically significant differences in questions Q8 ($\chi^2 = 0.038$; $p = 0.846$) and Q9 ($\chi^2 = 0.058$; $p = 0.810$) even though all the groups performed poorly in the two questions. Foundation group performed better than the non-Foundation group. However, it is evident that for question Q10 there is no statistically significant difference between the two groups ($\chi^2 = 0.026$; $p = 0.022$).

Figure 4.14(b): Percentage students' performance in questions about the net force acting on a car moving on a ramp

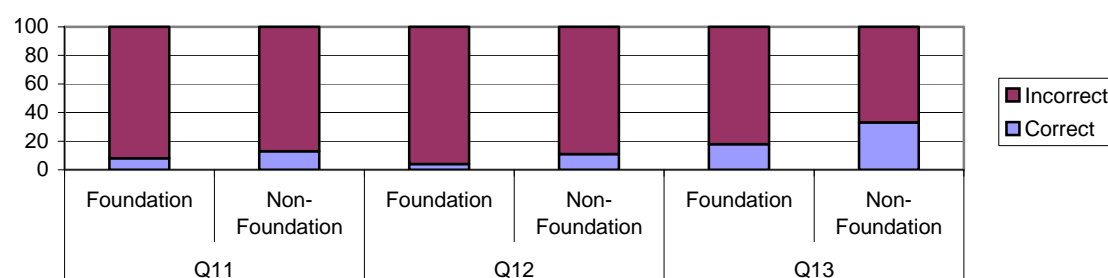


Q8: What is the net force when the car is moving up the ramp, Q9: The car is at its highest point, Q10: The car is moving down the ramp

Figure 4.14(c) indicates the response of students when they were asked about the forces acting on the coin that was tossed up. As in the case of Figure 4.14(b), the Foundation group and non-Foundation group performed poorly in questions Q11 and Q12 where the two questions are about forces during upward motion and at the top respectively. However, there are statistically significant differences between the two groups of students in questions Q11 ($\chi^2 = 1.030$; $p = 0.310$) and Q12 ($\chi^2 = 3.025$; $p = 0.082$). The performance of the two groups of students was better in answering question Q13, which deals with the force acting on a coin moving downward. There is no statistically significant difference ($\chi^2 = 0.026$) between Foundation and non-Foundation performance in question Q13. This indicates that the two groups of students have little understanding of the concept of force of gravity, with most students believing that it only affects falling bodies. In question Q11, most (69) of the students who chose an incorrect answer chose the one which says “the force is up and decreasing”. These students, thought when a coin is thrown up the net force that acts on it is upward and decreasing. 30 of these students belonged to the Foundation group. Some (42) of the students who chose an incorrect answer for Q11 thought “the force is up and increasing”. 14 of these students are Foundation group students. Out of 22 students who chose “the force is up and constant”, 10 are in the Foundation group. In question Q12, 139 students (56 Foundation and 83 non-Foundation) chose “the force is zero” because they believe when the coin is at the turning point there is no net force acting on it. In question Q13, most (83) students (37 Foundation group and 46 non-Foundation) chose “the force is down and is increasing”.

When asked in interviews to name some of the concepts they learned, only a few students mentioned gravity as one of the concepts. None of the non-Foundation group mentioned gravity as one of the concepts they learned.

Figure 4.14(c): Percentage students' performance in questions about the gravitational force acting on a coin that is tossed upward



Q11: What force acts on the coin when coin is moving upward, Q12: Coin is at its highest point, Q13: Coin is moving downward

Figure 4.14(d) indicates that Foundation group and non-Foundation group performed badly in all the questions except question Q15. However, it is in question Q15 where the Foundation group performed better than the non-Foundation group ($\chi^2 = 0.358$; $p = 0.535$). The reason why the two groups of students performed very well in question Q15 is because when “The car is at rest” means zero velocity and zero acceleration and zero force. This is easier for the students to interpret from the graph. There are however, no statistically significant differences ($\chi^2 = 5.258$; $p = 0.022$) in question Q14 and ($\chi^2 = 5.807$; $p = 0.016$) in question Q17. A large number of students (59 non-Foundation and 38 Foundation) chose a graph with constant non-zero force as the answer to question Q14, while other students (31 non-Foundation and 21 Foundation) chose a graph of force increasing constantly with time as the answer. The reason for these choices might be that students are interpreting graphs as a plane on which the motion is taking place.

In question 17, most students (34 non-Foundation and 29 Foundation) chose a graph with constant negative force while some (36 non-Foundation and 17 Foundation) chose a graph of constant decreasing force. As is the case with question Q14, the students might be interpreting the graphs as the planes on which the motion is taking place. However, all the groups performed very well in question Q15. It seems the students can easily interpret the graphs which involve stationary (or motionless) objects.

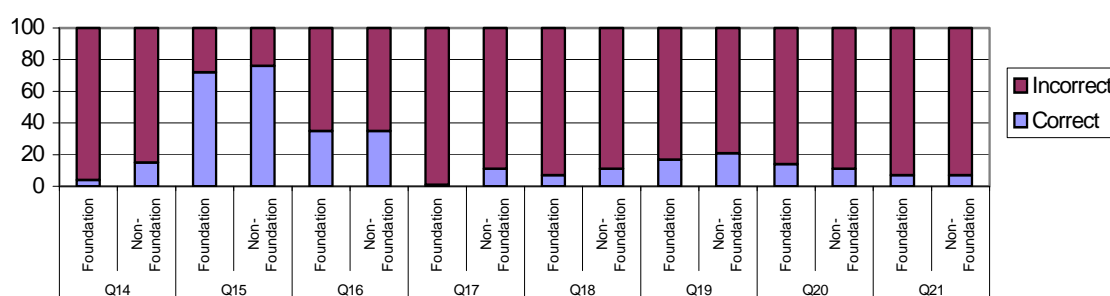
The second best performances of all the groups are in question Q16 where the movement of the car is towards the positive direction. This suggests that students understand Newtonian concepts when objects are moving towards the positive direction and fail to interpret motions towards the negative direction, and only if there is acceleration.

A good reason why the two groups did not do well as indicated by Figure 4.14(d) can be summarized by a comment from the Foundation group student:

S12: Graphs, I think graphs are difficult because sometimes you can't understand. They say it is proportional to what, what, and inversely proportional.

Even though only one student from those interviewed indicated graphs as one of the things that he/she does not like in Physics, most of the students did not do well in interpreting the Force graph question as indicated by Figure 4.14(d).

Figure 4.14(d): Percentage students' performance in force graph questions that explain the motion of a car



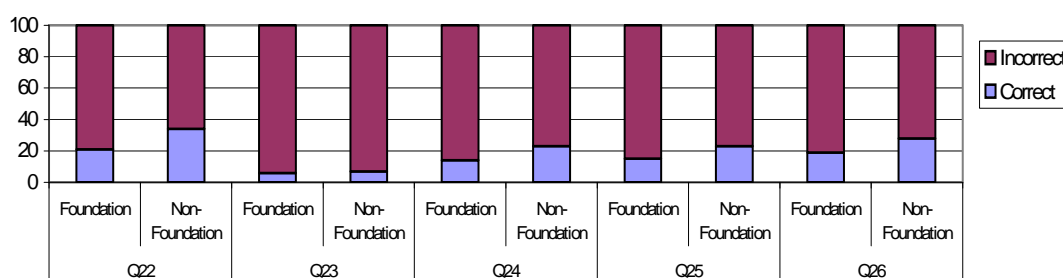
Choose a force graph that explains:
 Q14: Car moves to the right with constant velocity, Q15: Car is at rest, Q16: Car moves to the right with constant acceleration,
 Q17: Car moves to the left with constant velocity, Q18: Car moves to the right and slows down at constant acceleration,
 Q19: Car speeds up to the left at constant acceleration, Q20: Car moves right, speeds up and then slows down,
 Q21: Car is pushed to the right and then released.

In Figure 4.14(e), there is no statistical significant difference in question Q22 ($\chi^2 = 3.598$; $p = 0.058$). Question Q22 is about a car moving toward the right, speeding up at a steady rate. The students were able to associate “steady rate” with constant rate and they concluded that the acceleration would be constant. There are statistical

significant differences in all other questions, with Foundation group performing better than the non-Foundation group.

In the interviews, only one student from the non-Foundation group mentioned “acceleration” as one of the concepts learned.

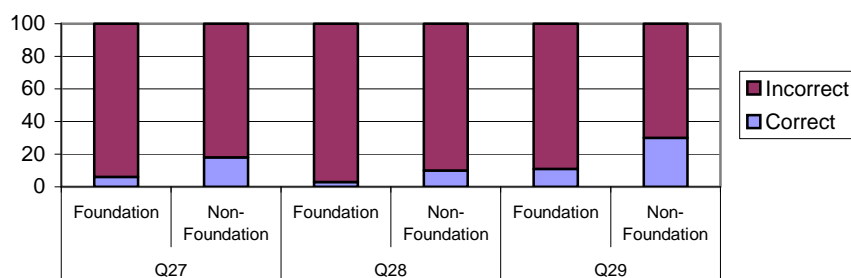
Figure 4.14(e): Percentage students’ performance in acceleration vs time graph questions



Choose acceleration-time graph that explains:
 Q22: Car moves to the right away from origin speeding up at a steady rate,
 Q23: Car moves right slowing down at a steady rate,
 Q24: The car moves left toward the origin at constant velocity, Q25: Car speeds up at a steady rate toward left,

The gravity questions are about a coin that is tossed up into the air. Questions Q27 to Q29 are asking about the direction of acceleration and whether it is constant, increasing, decreasing or zero when the coin is moving upward, at its highest point, and moving downward respectively. There are no statistical significant differences between the non-Foundation group and the Foundation group in questions Q27 ($\chi^2 = 6.074$; $p = 0.014$) and Q29 ($\chi^2 = 9.385$; $p = 0.002$). Figure 4.14(f) shows that both Foundation and non-Foundation groups had little knowledge about the concept of gravitational acceleration since they both performed as badly in questions relating to gravitational acceleration (Figure 4.14(f)) as they did in questions relating to gravitational force as shown in Figure 4.14(b).

Figure 4.14(f): Percentage students' performances for questions relating to gravitational acceleration of a coin

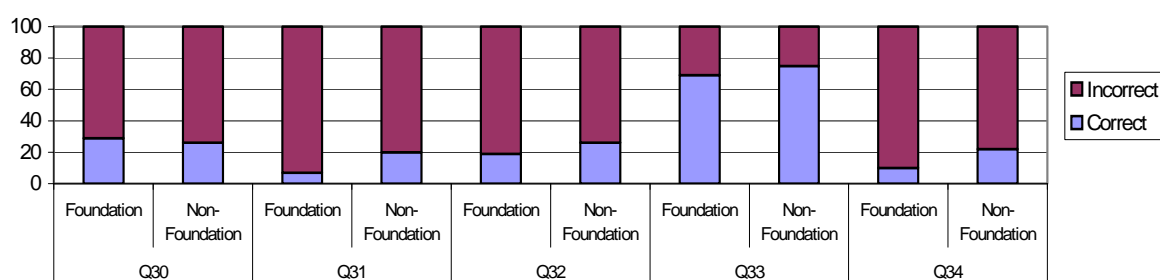


What is the acceleration of the coin when:

Q27: the coin is moving upwards after it is released? Q28: the coin is at its highest point? Q29: the coin is moving downward?

In Newton's third law questions, Figure 4.14(g), the Foundation group and the non-Foundation group performed poorly in questions Q31 and Q34 and it is on these questions that the non-Foundation group performed as well as the Foundation group. The Chi-square values are Q31 ($\chi^2 = 5.769$; $p = 0.016$) and Q34 ($\chi^2 = 4.824$; $p = 0.028$). The students in the two groups did not show a good understanding of Newton's third law. They only showed understanding of this law when both the truck and the car are moving at the same speed when they collide as in question Q33.

Figure 4.14(g): Percentage students' performance for questions relating to forces between the car and the truck



Newton's third law.

Q30: they are both moving at the same speed when they collide, (truck is much heavier than the car)

Q31: the car is moving much faster than the heavier truck when they collide, (truck is much heavier than the car)

Q32: the truck is standing still when the car hits it, (truck is much heavier than the car)

Q33: both the truck and the car are moving at the same speed when they collide, (truck is the same weight as the car)

Q34: the truck is standing still when the car hits it, (truck is the same weight as the car).

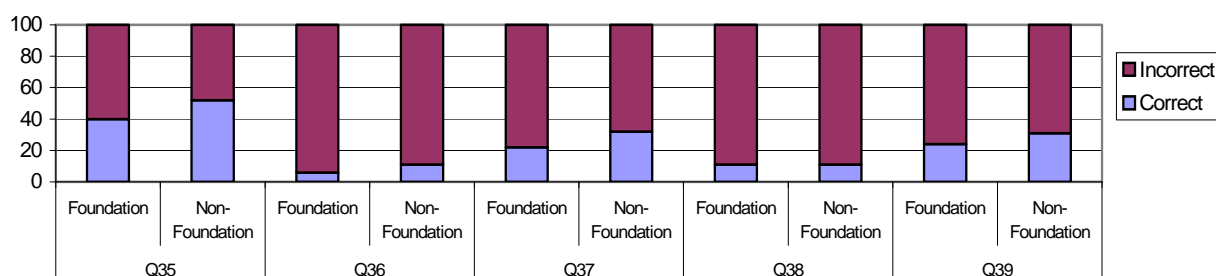
The students' performance in Figure 4.14(h) as in Figure 4.14(g) shows that the two groups of students did not understand the concept of Newton's third law. However in

question Q35 both groups performed better than on the other questions. In question Q35 students are asked about the magnitude of the two forces when the car is pushing on the truck but not hard enough to make the truck move. As long as there is no movement the students would think the two forces are equal in magnitude and in opposite direction, but when the two are in motion then the students fail to understand that the two forces are also equal in magnitude. When asked in an interview how they learn concepts, one of the Foundation group students said:

S15: ...It's not always the case where you just memorize what is in the book or what is written. You just have to take the key concepts and put them, put them together in your way.

This implies that at some stage students do memorize concepts without deep understanding. Some students had misconceptions about Newton's third law because as student S17 put it, they "take the key concepts and put them, ... in your way".

Figure 4.14(h): Percentage students' performance in Newton's third law questions



The size of the force between the car and the truck :

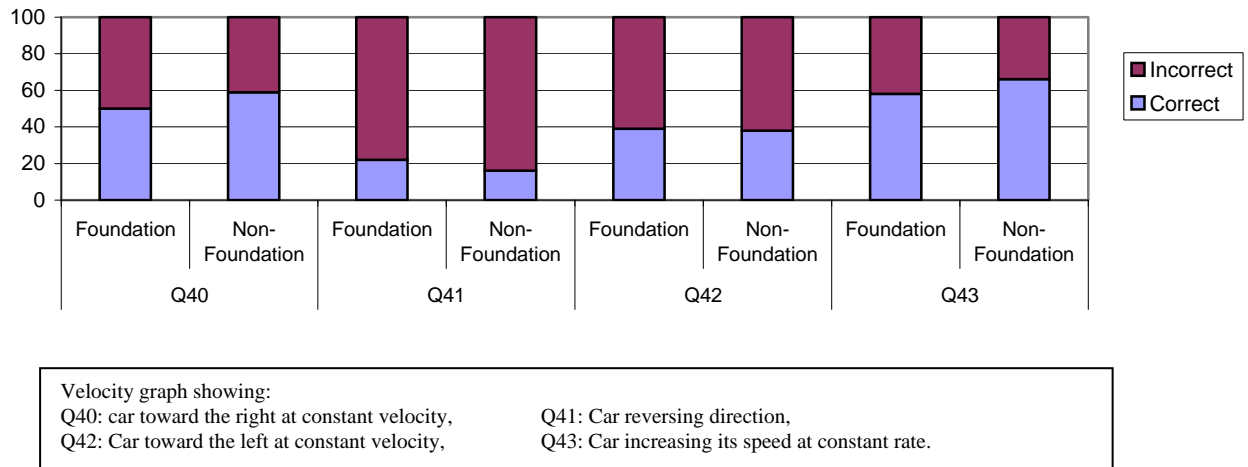
Q35: when the car is pushing on the truck, but not hard enough to make the truck move,

Q36: when the car pushing the truck is speeding up to get a cruising speed,

Q37: when the car pushing the truck is at cruising speed and continues to travel at the same speed,

Figure 4.14(i) below shows that students did relatively well on questions Q40 and Q43 in the concept of acceleration which was indicated in terms of velocity-time graphs. However, they still had problems in questions Q41 and Q42 when the car was reversing to the negative direction.

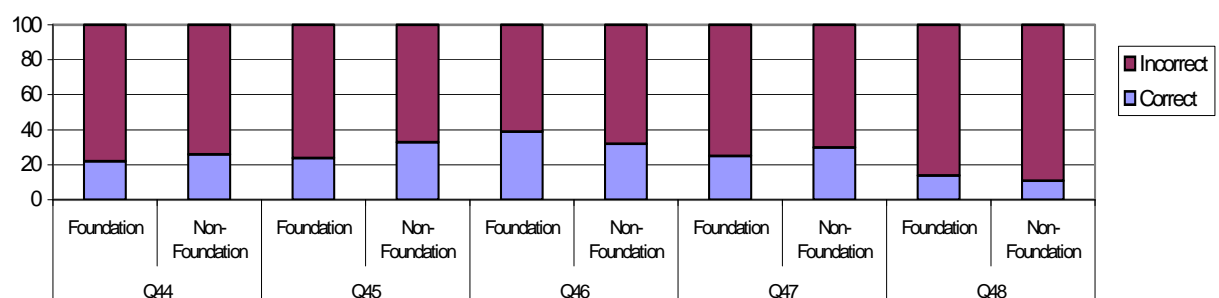
Figure 4.14(i): Percentage students' performance in velocity vs time graph questions



Students performed poorly in questions Q44 to questions Q47 with the Foundation group performing better than the non-Foundation group in question Q46. There are no statistically significant differences between the Foundation group and the non-Foundation group in all the questions in Figure 4.14(j).

If these questions were asked without giving multiple choice questions it is likely that most students would have got the answer to question Q46 correct. Although multiple choice tests are good at assessing factual level of learning (Chase, 1999:123), they fail to assess higher order process level skills (Chase, 1999: 125). Haladyna (1997: 4) indicates that multiple choice questions do not assess creative thinking. Students assessed using multiple choice questions are able to recognize the correct answer rather than to recall and/ or construct it on their own (Hakel, 1997: 4, Choppin, 1988: 774).

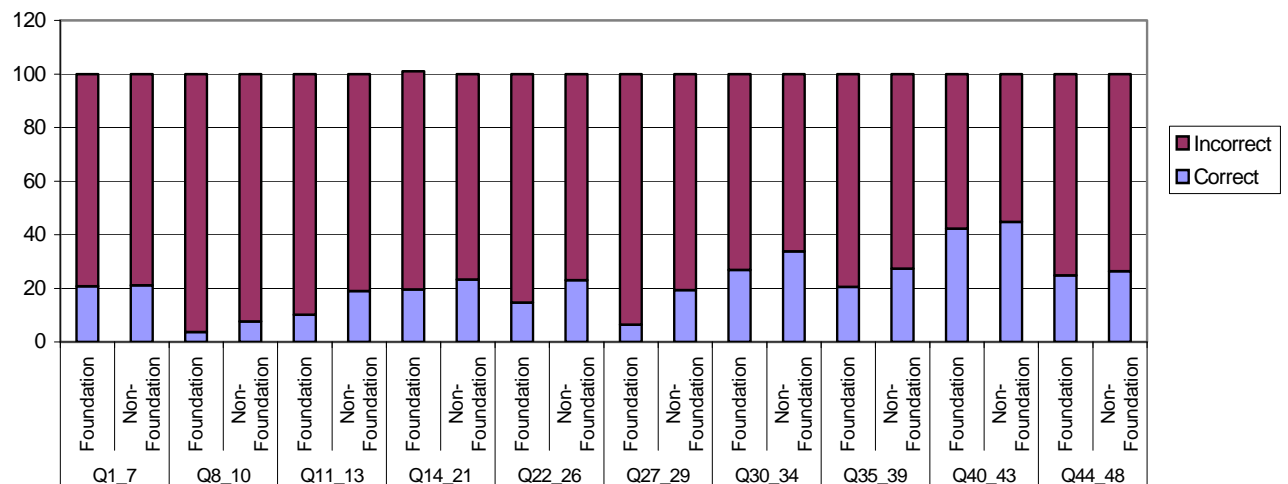
Figure 4.14(j): Percentage students' performance in questions relating to steeper hill



At the top of the hill the sled is released from rest and allowed to coast down the hill. At the bottom of the hill the sled has a speed v and kinetic energy E . Q44: what is the velocity of the sled at the bottom of a steeper hill of the same size? Q45: Compare the kinetic energy of the sled at the bottom for the original hill and the steeper hill, Q46: How does the speed of the sled (starting from the top of a higher hill) at the bottom of the hill compare to that of the sled at the bottom of the original hill? Q47: For the higher hill that is less steep, how does the kinetic energy of the sled at the bottom of the hill after it has slid down compare to that of the original hill? Q48: Describe in words your reasoning in reaching your answer in Q46.

Figure 4.14(k) indicates the average marks obtained for each of the group of questions that were presented before. SPSS's cross-tabulation was used to interpret the summed group data. There are statistically significant differences between Foundation group and non-Foundation group in all but one of the groups, i.e. Gravitational acceleration group (Questions Q27_29) where the two groups performed equally ($\chi^2 = 15.979$; $p = 0.001$). The non-Foundation group performed better than the Foundation group only in questions Q11-13 ($\chi^2 = 6.740$; $p = 0.081$). Non-Foundation students performed better than Foundation students in the other questions.

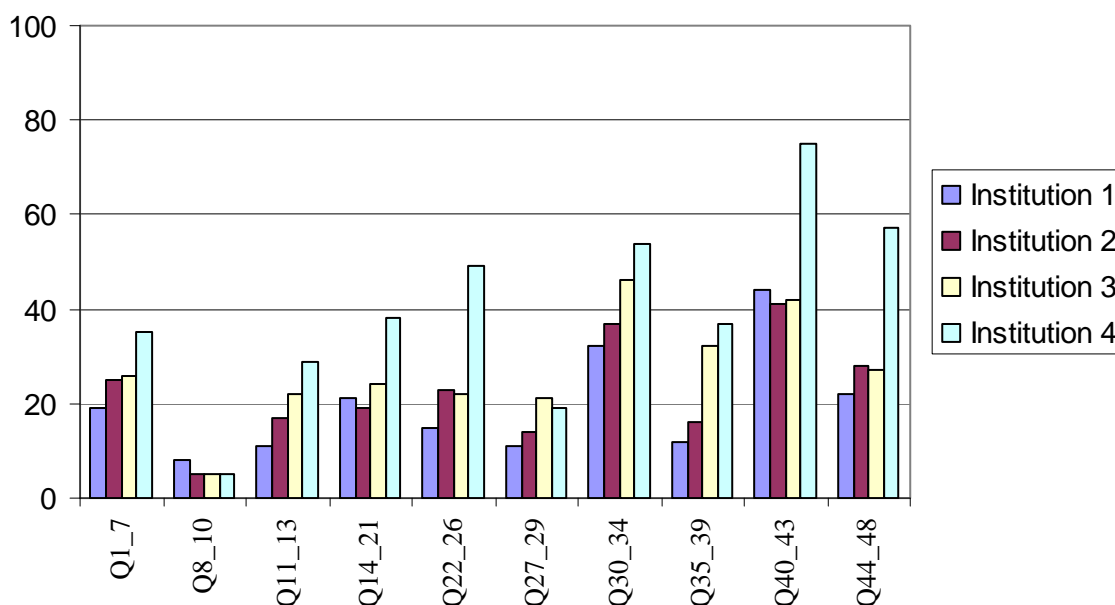
Figure 4.14(k): Group average students' percentage performance for Figures 4.14 (a) to 14(j)



In Figure 4.14(l) students' performances in the FMCE are compared by institution. With the exception of Institution 4, the three other institutions' performances are well below 50% in all the groups of questions. Institution 4 outperformed all the other three institutions in all but two groups of questions, and it is in those groups of

questions that all the institutions obtained an average percentage of below 25%. The two groups of questions relate to the concept of gravity. Figure 4.14(l) shows a pattern where Institutions 1, 2, and 3 obtained the lowest average percentage mark to the highest average percentage mark respectively in groups of questions Q1_7, Q11_13, Q27_29, QQ30_34, and Q35_39.

Figure 4.14(l): Group average students' performance for Figures 14.4(a) to 14.4(j) by individual institution



The average percentage mark for non-Foundation students from three institutions in mechanics exam is greater than the average percentage mark for the Foundation group.

Table 4.16 below indicates that the Foundation group at Institution 4 performed better than the non-Foundation group with a 5% difference. This is because there was one Foundation student who participated in the study. At Institutions 1, 2, and 3 non-Foundation groups performed better than the Foundation groups with percentage mark differences of 6, 5, and 6 respectively. However, taking into consideration the standard deviations, the two groups performed equally.

Table 4.16: Foundation and non-Foundation mechanics average percentage mark (standard deviation in parentheses) for each institution

	Institution 1	Institution 2	Institution 3	Institution 4
Foundation	46 (17.6)	41 (22.7)	51 (23.2)	85 (0)
Non-Foundation	52 (9.1)	46 (24.7)	57 (10.7)	80 (7.1)

4.4 Summary

The results show that neither the foundation nor the non-foundation students performed well on a conceptual test of mechanics concepts, the FMCE. Research (Thornton & Sokoloff, 1998) shows that students taught mainly by traditional lecture method perform poorly in conceptual questions like those in the FMCE. Students' poor performance in FMCE in this study is comparable to that in the study of Thornton and Sokoloff (1998) before the students were taught Active Learning Laboratories, even though the two studies were conducted in South Africa and the USA respectively. Looking at the overall performance (see Figure 4.14(k) and Table 4.16), Foundation students performed better than Foundation students in the FMCE and the two groups performed equally in mechanics exams.

Most students in this study obtained poor symbols in Grade 12 Physical Science (see Figure 4.6 and Table 4.8) and they passed Grade 12 in rural schools in the Limpopo and North West Provinces (see Figures 4.7 to 4.6 and Tables 4.9 to 4.11). While not justifying the poor performances of students in the FMCE and mechanics module, it is worth mentioning that many schools in the rural South Africa produce poor Grade 12 Physical Science symbols.

Chapter 5

Interviews with students and lecturers

5.1 Introduction

This chapter discusses results obtained from two sets of Focus Group interviews conducted from four institutions, i.e. two student focus group interviews and one Foundation Physics lecturer individual interview. The themes that emerged from focus group student interviews which are supplemented by inputs from Foundation Physics lecturer interviews are discussed in detail. The themes discussed in this chapter are: Grade 12 Physics background, what students aim to achieve with Physics, what students expected Physics I to be like, what helped students to understand Physics I, lecture section and lecturers, the effectiveness of the lecture section, discussions in class, how do discussions in class help students? the practicals, tutorials and tutors, exercises, tests and exams, students' expectations and attitudes in Physics I, acquired skills, conceptual understanding, students' confidence, physics workload, the role of Foundation Physics in learning Physics I, and Foundation Physics lecturer interviews. A separate section with additional information from Foundation Physics lecturer interviews is also provided.

Each university had two focus groups, i.e. Foundation and non-Foundation groups (see Table 5.1). The focus group students were selected from the number of students who wrote the FMCE test.

The students were selected according to their gender and performance in the FMCE test. The students targeted for each focus group were one male student and one female student who got the highest marks in the FMCE test and one male student and one female student who obtained lowest marks in the FMCE test. This selection represented the class population well. From Institution 1, five students were selected to represent the non-Foundation group because two male students performed well in the FMCE, and so the researcher decided to consider both of them instead of one.

Table 5.1: Focus group discussion sample

	Institution 1	Institution 2	Institution 3	Institution 4	Total number of students
Foundation	4	3	4	1	12
Non-Foundation	5	2	4	3	14
Total number of students	9	5	8	4	26

Students who did not turn up for the focus group interviews at Institution 2 were as follows: one male student in the Foundation group who did not perform well in the FMCE, one male non-Foundation student who did not perform well in the FMCE and a female non-Foundation student who performed well in the FMCE. Amongst the Foundation students from the Institution 3 there was one female student who performed well in the FMCE test and the rest were males. Only one female student who did Foundation Physics wrote the FMCE test. In selecting students to participate in the interviews, the researcher chose students from the two extremes hoping to get the greatest diversity in responses.

Physics I at Institution 4 had only one male student who did Foundation Physics and this was the only student who represented the Foundation focus group. Three male students represented the non-Foundation group from Institution 4. The fourth male student who was selected did not turn up for the interview. The only female student who did Physics I at Institution 4 did not take part in the research.

Table 5.2 Student numbers of Foundation and non-Foundation students from all four universities

	Student numbers
Foundation Students	S1, S2, S3, S4, S10, S11, S12, S15, S16, S17, S17, and S23
Non-Foundation Students	S5, S6, S7, S8, S9, S13, S14, S19, S20, S21, S22, S24, S25, and S26

5.2 Grade 12 Physics background

Physics forms part of Physical Science in Grade 12 and therefore marks in Physics at school contribute to a final mark in the latter subject. Students who do not acquire good grades in Grade 12 Physical Science do not qualify for admission to Physics I courses at universities. The entrance requirements for Physics I course differ from institution to institution. In order to prepare students for Physics I, most universities run a Foundation Physics course for an entire year.

When asked how they prepared for Physics I, the Foundation group students indicated that Foundation Physics [bridging] helped them to prepare for Physics I, as indicated by the comments below.

S1: I did Foundation [Foundation Physics], and I got distinction in Physics [Foundation Physics] and I just decided to do Physics [Physics I].

S2: Myself I did very bad in matric, so I was, I wanted to do something related to Physics at tertiary level, so I went for a Bridging course. So, from there I got all the foundation, all the basics, and that enables me to go forward with physics.

S3: With me, I did Science Foundation.

S10: Myself I started doing bridging physics as well, so that I can do Physics first year.

S12: Even myself I started doing physics with that of bridging and then as the time goes I feel, I think physics was good for me, and then I'm prepared to go on with physics.

S15: It's like I went to the Foundation Physics and at least I managed to get a place in Physics I.

S23: Last year I was doing Foundation Physics and I passed with distinction, and now I am in Physics I this year.

Students in the non-Foundation group, even though they come from similar school backgrounds as the Foundation group, performed better in Grade 12 Physical Science examinations. Most of these students worked well in Grade 12 to get good symbols. When asked how they prepared for Physics I, non-Foundation students responded as follows:

S13: Well, in Grade 12 I studied to get a better symbol in Physics, that's what I have been doing.

S14: In Grade 12 in Physics [Physical Science] I worked hard. Then I got a good symbol.

S21: I started with General Science, and we did Physics and Chemistry from Grade 7 up to Grade 10. Then is then that I realized that physics was problematic at that time. And in Grade 11 we started to do practicals, I realized that with practicals, then I started liking physics and in Grade 12 I got distinction but in Standard Grade.

S25: ... We were, our school was not having so much facilities in terms of the practicals and some of the teaching materials, we were not having them, the teaching material for physics, and it's been a little tough for me in the preparation of my physics from matric to university one.

A factor that most students (Foundation and non-Foundation) claimed was a disadvantage in coping with Physics I was a lack of apparatus at school to perform practicals. Indeed we cannot expect students from schools without well-equipped laboratories to perform as well as those from well-equipped schools.

5.3 What students aim to achieve with Physics

Foundation group students from three institutions indicated they were not going to choose physics as one of their majors, either because they consider it as difficult or they would like to take another profession besides physics.

Very few non-Foundation group students from three of the universities in this study indicated that they would like to take a career in Physics. Amongst these students, there was one student who had intensions of doing Medical Physics at a later stage. Of the few students who were interested in a career in Physics, some, like S13 were still not fully decided.

I: Tell me a little about the ideas you have for a major, or possible plans for your future professional life. What do you want to major in, or what do you want to be?

S13: Up to so far I can say I'm not sure, sometimes I like to go on with Physics but I have got a problem with job opportunities. Now and then when I look at the newspapers I don't find Physics jobs then I get discouraged. So far I don't know what to do. May be Chemistry, I don't know.

Until recently few jobs in Physics were advertised in newspapers. Jobs that were advertised were either not paying enough or were senior positions. Most students from all the two groups in three of the four institutions indicated that they were not going to major in Physics. However it was pleasing to find that almost all the students from Foundation and non-Foundation groups in the fourth of the institutions indicated they will major in Physics because they find it interesting and they like it. Some of these students got motivation from Foundation Physics and their school teachers. The quotations below come from students at this institution.

S15: ...even if I want to do something I can go and pursue while having physics, and I just like physics.

S17: I also like to major in physics because I think it has a broad spectrum in what one wants to do because I was also interested in the fields of engineering and all that,... I think from previous years, the way my teachers were teaching and even in Foundation, I started realizing that that's where I have an interest.

S19: 'Nna' [me] I'm majoring with Physics because I want to do physics major and Chemistry. I don't actually know what can it take me to, Physics. But I'm doing it since I have heard that it has great opportunities and with Chemistry it's gonna be good. And then may be I'll do astrophysics. Opportunity there, I don't know, but I'll continue with Physics and do honours and pass. Actually when I came I was not intending to do Physics, but since I started doing it, then so far I'm intending to go far with it.

S20: Even me, I am, I registered Physics, let me say my major is going to be Physics, may be followed by applied... I like electronics so much, so I want to, if either I need to know about that electronics, and that physics, you can see may be for the second module when let me go out to make use of that electronics. ... I try to enjoy physics because is, is, physics is happening in real life. ...Actually I need that one of electronic, may be to tamper with television, but I don't want to break, just to see.

S21: Same to me, I am majoring with Physics and Chemistry. I realized that Physics that we are doing is very much broad that can allow one to do any career in Physics. To do any career in Physics, actually I need to go and I realized that the Physics that we are doing is similar to the one that they are doing at the technikons, I think if I can go with this one and graduate may be I can cope with anything.

Students from this institution (which will be referred to as Institution 3 in this study) indicated that one of the lecturers allows them to discuss in class. They also indicated that they do not have problems with tutorials and practicals. The Foundation and non-Foundation groups in each institution had similar views about their future careers. Student's career choice seems to be influenced more by the institution in which the student is registered and the lecturer's teaching style, and not by whether the student did Foundation Physics or not.

5.4 What students expected Physics I to be like

The non-Foundation group students expected Physics I to be difficult because they came from schools where they did not have practicals. Once they were registered for the Physics I modules, they found them interesting and simple especially when the lecturer gave examples that are known to them.

I: What were your first impressions of Physics I?

S5: At first I thought it was hard, but when coming to testing it seems a little bit easier than at school because sometimes at school we don't have many facilities, but here is better, you see some practicals, at school we are just assuming.

S13: Well, it was very much interesting, ja [yes], we have learned new things and then we have a better idea of things we learned previously, then it was interesting mixing old skills and new skills.

S24: I was scared. I was told that physics is challenging and it's gonna keep me. I was once at one stage I was supposed to cancel physics and register for the other course, but I said no, I have to face my fear, then I went for physics, but I find it very interesting and easy to study, the way it was conducted, the way the questions were asked, everything about physics, the practicals. It was cool.

S25: ...I thought first that Physics I is gonna be difficult, since my physics from matric I thought it was the difficult physics. But I first found that it was the most what-I-call easy physics to me, not just because it's naturally easy, but the way it was conducted it became so easy to me.

S26: I thought that Physics I is simple because what you are going to do is just the continuation of Standard 10 [Grade 12] work.

Even after undergoing Foundation Physics course, the Foundation group still feared Physics I and the reason for that might be, as student S11 indicated, Foundation Physics is similar to High school Physics. Students S11 and S12 from Institution 2 thought that there were no connections between Foundation Physics and Physics I.

I: What were your first impressions of Physics I?

S12: Myself I thought it would be similar with those ones I did in Bridging, but then when I came, I just, I just, I have seen that no, this is major is not that one, Bridging, is major, so I think I tried my best.

I: How are they different?

S11: This one of major, of Bridging is just high school physics and this one is, I think ja, university physics.

Students view Physics I and Foundation Physics as two disjointed entities. This is also supported by their lecturer L3, who when asked how he would describe the teaching approach, indicated that

L3: ..., the teaching approach in Foundation Physics, eh is different from the one that we normally do for the first year students, ..., the reason being we are trying to bridge the gap between what should have been learned in high school with what we expect the student is supposed to know in the first year level. So it means that in our Foundation Physics we make it a point that the work which was supposed to be taught in, in brief in high school, matric especially, it was supposed to be done properly so that when these guys are doing first year physics they now understand what is it that they, I mean the basics introductory knowledge. They should have that one. But it is too demanding in the sense that you need to be very patient with these students because some of them are coming from poor backgrounds. You need to understand them. Then their level of understanding of Physics is also down. You must try to integrate all these things and then, and bring students to the level of which when they come to the first year they really understand what they should have learned in matric.

When asked how the emphasis in Foundation Physics course compares with the emphasis in Physics I, lecturer L3 indicated that Foundation Physics lays a good foundation for students to be able to cope well with Physics I. However, students fail to see the continuity between Foundation Physics and Physics I. This is how the lecturer responded.

L3: Well, like I said, the relationship is in such a way that we teach something that was supposed to be taught in matric and then coupled with the introductory sections on what they are supposed to learn in their first year level. So it means that if someone went through the Foundation, our Foundation programme they should be able to know or understand most of the basic skills that he was supposed to learn in high school and also try to cover some introductory sections which he is supposed to study in his first year. So that is where the relationship is. The moment we went through that particular Foundation, when he goes to first year it becomes easy for him to, because the introductory sections may be he got it in the Foundation programme. Just helping to give introduction of what they are supposed to learn in their first year.

The Foundation group from the institution (Institution 3) with most of the students who would like to major in physics expected Physics I to be difficult but through dedication, that all changed. Students believed that with the good attitude and dedication anyone could succeed.

S15: ‘Nna’ [me] I thought, I also thought that physics is difficult but as time goes on I realized that it needs practice in order to improve.

S16: Ja, it is challenging course but really it depends on whether the person is good enough and having the feeling to do physics, but if you are having that feeling that you want to be a physicist, then you can make it.

The non-Foundation students S24 and S25 from Institution 4 thought Physics I would be very difficult. However, after attending some classes they found it to be “cool”.

S25: ‘Nna’ [myself], what are my first impressions, being that I thought first that Physics I is gonna be difficult, since my physics from Matric I thought it was the difficult physics, but I first found that it was the most what-I-call easy physics to me not just because it’s naturally easy, but the way it was conducted it became so easy to me.

S24: OK, hey, for me, hey, hey, I was scared. I was told that physics is challenging and it’s gonna keep me [busy]. I was once at one stage I was supposed to cancel physics and register for the other course, but I said no, I have to face my fear, then I went for physics, but I find it very, very interesting and easy to study, the way it was conducted, the way the questions were asked, everything about physics, the practicals. It was cool.

Most students from both Foundation and non-Foundation groups expected Physics I to be difficult. However, after attending some modules some students found it easy to follow, mostly because they liked Physics I. There were, however, students who still did not like Physics I even after attending some classes.

5.5 What helped students to understand Physics I

Some Foundation group students like S2 and S4 used the library resources to supplement the lecture. Other students valued practicals and tutorials because they helped them to understand Physics I.

- I:* If you were to specify one thing that helped you to understand Physics I what would it be?
S2: I was attending classes, so I combined what I learned from the lecture by reading different types of textbooks....
S4: What makes me to survive in Physics, is the only way that I know that in prescribed books in the library before I attend the class rather than attending a class without, knowing nothing.
S3: When we are in practicals, when I see something, OK, I read some books then I see it, then it is going to be there in my mind and I will always remember it, this thing I saw doing this and that when I was in the practical. So I like practical.

All the Foundation group students except S23 failed to indicate Foundation Physics as a course that helped them to understand Physics I. However, some Foundation students mentioned other things that helped them to understand Physics I.

The non-Foundation group students S5, S6, S19 and S21 from two institutions cited practicals as one of the things that helped them to understand Physics I. Classroom discussions also help students to exchange ideas and understand most of the concepts as is indicated by S25 from Institution 4. Amongst other things that the non-foundation group mentioned were tutorials.

- I:* What really helped you to understand physics?
S21: Ja, to get contact I think it's the right thing to do practicals, because in theory if you don't understand, when you go to the practical you can take a long time talking about the things that they taught us, if you don't understand, they don't just allow us to move without understanding. You can take more than 4 hours trying to understand what he taught us up until now.
S25: 'Nna' [myself], what I like is eh, the lecturer allowing us to engage in a participation of the, the discussion in the class. And that gave me, or that broadened my mind with respect to physics. That's one thing that helped me a lot.

Only one student from the Foundation Physics group indicated that Foundation Physics course contributed to the understanding of Physics I. However, this does not imply that Foundation Physics did not prepare the Foundation group for Physics I. It might however, mean that they never thought it was important to mention. Most of the non-Foundation group students indicated that practicals and discussions helped them to understand Physics I. Very few Foundation students mentioned practicals as one of the things that helped them understand Physics, possibly because they had done a lot of practical work in Foundation Physics and were now familiar with practicals. Non-Foundation group students mentioned practicals and discussions as things that contributed in their understanding of Physics I because they never had those experiences before.

5.6 Lecture section and lecturers

A traditional lecture where the students listen to the lecturer without discussion limits student learning. However in large classes this is the only method that the lecturer will resort to. It would also be difficult to give attention to individual students' needs as suggested by Foundation group student S2.

I: Can you describe the lecture section of your class? I want to know, what does the lecturer do, and what do you do in the lecture room, in the class?

S2: I think, as for me, I see the things in different ways, we are having good lecturers here, so knowledgeable lecturers, but one thing that I saw that was lacking is that there is not, not enough attention given to students especially individually. We are many, so we must understand that physics is so tricky, you know. So we must make sure that they attend to each and every student individually to, a sort of motivation to inspire us to work harder, something like that, 'kuri' [because] to change your attitude towards physics is more of a mental thing. They should create an environment conducive to us students so that we can, before teaching there should be a must that we are in good shape of mind and we are positive even the right attitude towards physics, because they know what is there in Physics.

Foundation group students were given lot of attention in class. This however may result in them being more dependent on their lecturers. Foundation Physics lecturer L4 indicated that students should be guided and mentored as indicated by the comment below.

L4: ... We kind of also act as a mentor to these students because once you lecture them, you just give them the information and swallow it and leave them to digest it on their own. But what we are doing here, we, we sort of guide them in how to go about learning to go about many things, how to go about solving different kind of problems.

... in first year I would say that students when they get to first year there, there is no one, no one who really try and follow them in their job. It's like, "guys you have been taught and you come from high school, you should be knowing how to go about doing your work," and all those things.

At Institution 4, a Foundation group student S23 pointed out that students were not only interacting with Physics I lecturers by a way of answering questions, but they were also given presentation tasks where they present on a given topic.

S23: Most of the time the lecturers would come to class, and we discuss most of the time, write notes and present some of the lectures, us as students, so they were quite fun.

This allows students to interact with the lecturer and other students with ease. The responses from the non-Foundation group were not different from the ones made by the Foundation group. As in the case of the Foundation groups, the traditional lecture

method, where the lecturer will write notes and explain, was followed in almost all the institutions. Some students like S13, S19 and S21 were concerned about lecturers' teaching style. They indicated that their teaching style leads them into memorizing without understanding. Student S19, who is in a non-Foundation group said students do not like lecturers who would ask them to prepare for a class beforehand.

I: Can you describe the lecture section of your class? What does the lecturer do, and what do you do as a student? When you are in the lecture.

S19: ...and tell you "read ahead." You have to know these twenty pages by tomorrow, before you come to class, then tomorrow he'll just page those pages like going through just like that. And we won't understand, we just, you know us students, we don't actually, if he can tell us to do this chapters, twenty pages, we won't do them. May be you just go through them, few of them or just one page and go to the lecture, and you get there and the lecturer just go through them not actually being precise, ja. The lecturer, that's teaching us now, he spends most of the time like explaining things, he'll talk about how are they in real life and what impact are they doing to us, to our trees, ja, so I like him.

Most Foundation group students needed more lecturer mentoring than the non-Foundation students. This was also supported by some of the Foundation Physics lecturers' comments who indicated that students should be supported throughout. Only one student (S19) in the non-Foundation group complained about the lecturers that give work for students to do before a class.

5.7 The effectiveness of the lecture section

Some Foundation group students still expect to get more help from the lecturers even after they have done Foundation Physics. They believe lecturers need to spend more time with them even though it is difficult for a lecturer of a big class to spend more than stipulated time with all the students. Below are their comments:

I: Do you think your lecture section is an effective way for you to learn Physics?

S2: It is effective but, as I already mentioned, there is some space for improvement, like the time we spend with our lecturer, I don't think it is enough more especially because the amount of work we didn't do as students is big. So we must try to increase the time we spend together, may be in the form of extra classes, and we treat questions, many questions, not many questions, as many questions as we can, by so doing we will improve.

S10: No, I don't think so because they just come and give us those notes and then give us examples. They don't just explain a lot. We can't learn physics by just writing.

S11: Even with myself, I don't think so, I mean, it's on both sides because sometimes if I don't understand and I go to class I find out that this thing if I didn't come to class I wouldn't understand. And sometimes I just go to class to copy notes, write examples and I don't understand why.

S12: I think some of those lectures make us to understand because it's something that we come across in life

Instead of increasing the time the lecturers spend with the students, the best way would be to have small groups that are monitored. The Foundation Physics lecturer L4 at the same institution where S2 is a student supported the idea of dividing students into small groups.

L4: Yeah, the teaching approach basically is we first of all divide the students into groups randomly, random groups. We don't just say those who are doing that with those who are doing that. We just combine them randomly. The reason being that students, they should be able to learn from one another and the strongest one should get involved, in a way in learning he should be teaching this other ones.

When asked about the effectiveness of a lecture, Foundation group students S10 and S11 from Institution 2 thought the lecture section was not an effective way for them to learn Physics because they were always copying notes in class.

S10: ... they just come and give us those notes and then give us examples, they don't just explain a lot. We can't learn Physics by just writing.

The lecturer who taught these students Foundation Physics indicated that he taught them in a way that emphasizes both conceptual understanding and problem solving. However, the way they were taught in Physics I did not emphasize conceptual understanding.

The non-Foundation group students S5 and S6 said it's a duty of students to make sure that they supplement the lecture by reading some other books and also interacting with friends.

I: Do you think that your lecture section is an effective way for you to learn physics?

S6: Because sometimes even if you attended the class you don't get it clear what was said you need may be to read some book and find out may be from friends.

I: OK, any other thing?

S5: But may be because something is said in class you get interested, you want to know more about, then you go back and read, but without knowing, without the lecture, you just sit there, you don't know anything.

Lecturer L4 teaching at the same institution supports student S6's comments about the lecturers in Physics I.

L4: In first year, I would say the lecturer comes in and he just dictates to them, for example introduce a chapter and he goes to lecture them, writing the notes, writing on the board and so forth and so forth. And then give them the tutorial. They don't just sit down and find out whether this one understands this and this.

Foundation and non-Foundation groups differ on how they regard a lecture method. For example, non-Foundation students S5 and S6 indicated that if they do not understand what is said in class then they supplement a lecture by “reading some book and find out may be from friends. Most of the Foundation group students did not indicate the alternative methods that they could use when they fail to understand concepts in class. Non-Foundation group students do not have problems with a lecturer who gives them notes without explaining. Non-Foundation students were taught using mostly a lecture method in high schools, whereas some Foundation students were exposed to teaching which allows them to interact with lecturers and other students. Though discussions in class can build students, the students need to be given a chance to work on their own without the help of the lecturer.

For the most part, the teaching approach used in foundation courses could be described as interactive, while the approach used in most Physics I courses is traditional in the sense that most of the time students sit quietly while the lecturer delivers a formal lecture. Although Physics education research has shown that an interactive teaching method leads to better student understanding and therefore is desirable in foundation courses, it seems to be difficult for students who have experienced this approach to then cope with a traditional approach.

5.8 Discussions in class

According to comments from Foundation group students S2 and S3 from the same institution, there was no discussion going on in the lectures. Discussions took place in tutorial sessions.

I: Tell me what you think about the participation element of the lecture, that is, when you are in the lecture, when your lecturer asks you to either raise your hand and answer a question or the discussions that you hold amongst students.

S2: It depends on the lecturer, but there is not much of the discussions, they are very rare.

S3: It's very rare, we never have time of coming and discuss about things. The lecturer just come and say whatever he wants to say, and he asks may be one question. It's little, and sometimes.

I: OK.

S2: Normally we ask questions during the tutorials, that's where we ask questions, but during the lecture time it's all about listening to the lecturer.

As in the case of the students' views about a lecture method, lecturer L4 indicated that the only method used in teaching Physics I is a traditional method.

In Institution 4, Foundation group student S23 indicated that they did discuss in class.

S23: That participation element is very good because the students can talk among themselves, discuss it, and then it's easier to answer any questions there.

All non-Foundation students interviewed at Institution 2 indicated that there were no discussions in class and in some cases students didn't even ask questions because they feared they could be nicknamed after a wrong answer as pointed out by S13 and S14.

I: OK, what do you think about the interaction that you get between you and the lecturer, when the lecturer asks you to raise your hand, or when you are given a chance to discuss something, a certain concept among yourselves in class?

S14: When you ask the question people just do not participate because when the, when the person asks a question the other person will laugh.

I: OK, so some students laugh at, when you answer?

S14: And you can get a nickname from that (laughter) for the wrong answer you give, your name is after that mistake.

I: Why do students laugh?

S13: I don't know, our attitudes are, and I don't know what happens, because if I give irrelevant answer I'll be named after that. They'll be calling me that outside. And next time I won't answer.

I: Now, what do you think should be done to stop that?

S13: May be the motive, we should, we should be taught how to behave, and ja.

I: Now, what are the remarks of the lecturer, when somebody laughs at other students?

S13: They are also against it but nothing they can do.

I: But you ask questions?

S13: Ja, only those who are bold enough (laughter).

Non-Foundation group students do not like to be laughed at, whereas Foundation group students are confident since they have adapted to the university environment through attending Foundation Physics. This allows Foundation group students to ask questions in class with ease.

5.9 How do discussions in class help students?

The Foundation group students from two institutions that have class discussions indicated that it's easier to understand the concepts through class discussions.

I: How if at all do they help you learn physics, these discussions?

S15: It's like if, if, if, Ok always it's like we won't understand in the same way someone may be understanding the aspect, much more better than I do, then if we like share it, it's where I think we can learn.

I: How do you find discussions in class (S16)?

S16: Like we, we benefit from them and after the discussion that's where you'll now understand something much better if you didn't learn something.

S23: They help you because you can get the perspective, ja, your fellow students and what they think, and then one you discuss this thing, OK, it's easier to go to the right answer and to understand it.

The non-Foundation group students from the same institutions that have class discussions also affirmed what the Foundation group students from the same institutions said.

I: How, if at all do they help you learn physics? This discussions that you are having.

S19: Everyone comes with her own opinion and explanation and you know everyone comes with their brains, how do they understand and we actually learn from one another. We actually, may be you had, you know, you knew the lecturer but then when somebody comes and pour more information to your head, ja, it gets interesting. You learn from one another.

All the Foundation and the non-Foundation groups from two institutions (institutions 3 and 4) that practiced class discussions indicated that class discussions were very helpful. However, students from the other two institutions indicated that there were no discussions in their classes.

5.10 The practicals

The Foundation group students from Institution 1 were dissatisfied with the way that Physics I practicals were run. Some students went out of the laboratory session not having touched laboratory equipment because of the large numbers of students sharing only a few sets of laboratory equipment. This was indicated by students S1, S2, and S4. One of the concerns is that some student assistants were not competent enough on their job specifications.

I: Can you describe the practical section of Physics?

S1: Very bad.

S2: Like here in the practicals, there are many, many loopholes, we are sharing equipment, so during the practicals some students are, we can't all, like if we are using let's say a massmeter, we can't all put our hands on that. So, you'll find that the other students doing it, I think somewhere, I think that is the main thing that is contributing to less standards of our practicals. We are many.

(they all laugh)

S4: Some people are not contributing, they are not contributing. If we take him or her, and ask him

“what are you doing, she will never, or he will never tell you because he did nothing.

S2: I think the main cause of that is that we don't have knowledgeable people to assist us, like the student assistants. There are some that are good, but many they are not good. They are sometimes even afraid to ask, 'ke ra' [I mean] to, to tell. They are unable to answer some of the questions posed to them by the students. So I think that part, practical part needs a bit of attention.

S1: And I think it's because of lack of facilities, lack of apparatus, lack of people who know what the practical is all about, because we do practicals with the student assistants. We don't have lecturer for, for, for practicals. They say he is there but we have never seen him there. So normally we do our practicals with student assistants.

The Foundation group students from three of the four institutions were happy with the way practicals were run. Their comments are as follows:

I: Can you describe the practical section of Physics I? What happens in the practicals?

S10: We come to the lab. We already have our manuals, ja [yes] we stay with them, then we come to the lab and find that they, they have provided us with those equipments which we have to use. Ja [yes], then we start to perform [the] practical. If we don't understand something, we ask from the demonstrators. Ja [yes], they show us, then we go on to doing the practicals, and after that we have to show our lecturer the results that we got. If they are wrong, he says “go back and repeat” until we got correct results. Then we go and write the report

S12: I think it is easy because we have a manual. We prepare ourselves before we can come to the lab. When we come to the lab we already know what we are going to do.

S15: Ja [yes], they are challenging but it really depends on what is it that you understood in class about what you'll be doing. It's like the continuation of what you did in class or the practical thing of what you did in class.

S16: And after practicals you'll understand much better than before, like you understand what you did in class much better:

S17: I think it's where I enjoyed most during the time I was doing physics, because you get to see whatever you are performing if may be you got it right. That boosted one's morale that at least you can do something.

S18: I think there is a pre-question that you have to submit, and they explain what to do.

S23: The practicals, we just go to the practical lab, and prepare for the practicals. It's the things that we do in the theory in class, and we do them in practical in the lab.

The non-Foundation group students from Institution 2 indicated that although they come to practicals fully prepared they are not happy with the service they get from the demonstrators.

I: Can you describe the practical session of Physics I?

S13: Eish, for me it's a very, very big burden (laughter). You come to the session without knowing what you are going to do. Just a little idea, and then you spend most of the time struggling with the equipment, and there are few demonstrators who will come and help you, so we need more demonstrators.

I: So, you don't have enough demonstrators?

S13: Ja, and you have to wait for 30 minutes if he is helping another one, another group and it takes a lot of time.

I: And yourself, what happens when you are in practicals?

S14: When you connect the apparatus, and you cannot connect the apparatus, when you call the demonstrator to come and help you he will come late.

I: Because he is busy somewhere?

S14: Yes.

I: OK, so, you start the practical yourselves, or what happens before you start?

S13: We come in, then we start. Then we have to call them if we are not understanding or we are missing something, you call them to help you.

I: OK, so you prepare, what happens before the practicals, you come prepared or what do you do?

S13: Ja, we come prepared, we study the manual so that we can do things fast and then leave early.

At Institution 3 all the students in the non-Foundation group are happy with the practical component of Physics.

I: Can you describe the practical session of physics?

S19: OK, it's great there, they are very strict and it's helping us to concentrate on what we are doing, and to actually make sure that you are doing the right thing and to actually understand what we are doing. It's great there.

S20: Ja, in practical I like, actually I like practicals a lot because we are using our hands to work. Even if you can see when I'm speaking I'm using hands, I like to work, because we are working when we are demonstrating Ohm's law, you can see that Ohm's law is electricity in our homes. At lab is just a bit of what we are doing at home and myself, on my own I did it and switch on and it lights.

S21: What I like is that sometimes we are working in pairs and there are many lab assistants, and they give us time to perform all those things and consult them, and if you fail to understand, then, they'll let us repeat until we understand them.

One other non-Foundation group at Institution 4 indicated that they were very positive about the practicals. They also indicated that they now have access to laboratory equipment unlike at secondary school where they had nothing.

I: Can you describe the practical session of Physics I? What happens in the practical session?

S24: OK, ja [yes] it was good because they also even show us how, how can we apply physics in real-life, how can we like use physics in our everyday situation. At school, the way they demonstrate to us, "OK, this is what, like the instrument, they tell you the name. ...you'll know how to use that thing, and you are tested to use that experiment. And you perform an experiment alone as a form of exam. I think that was very good.

S25: Eh, practical session eh, they were, they were good and, because of especially to, to me because of eh, from my high school there was no what-you-call, more of the materials or the facilities that we are having now. And I just find them interesting, and I have learned a lot because of, it's like I was during practicals with more of equipment.

All students interviewed at Institution 1 were not happy with the way practicals were run. At Institution 2, non-Foundation students were not satisfied with the way practicals were run. However, Foundation students from Institution 2 together with Foundation and non-Foundation students from Institutions 3 and 4 enjoyed practicals. These results indicate that the majority of Foundation students from all the institutions

as compared to non-Foundation students were happy with the way practicals were conducted.

5.11 Tutorials and tutors

Tutorials are a useful tool for making sure that students grasp concepts they failed to understand in class and also treat several problems relating to concepts taught during a lecture. However, some of the Foundation group students were not satisfied with the level of preparation of the tutors.

I: Can you describe your tutorials? What typically happens during tutorials?

S3: It's disgusting, when we do tutorials we expect student assistants to assist us but sometimes it is a miracle to see those people who are doing third year, they are similar to me, they don't know nothing. They fail to explain to me then they don't, they don't show any, any interest in there. You can spend 90 minutes doing one problem without getting a solution. I think if the lecture, the lecturer, he or she attends the tutorial, may be there is something we can talk about it. But as long as the assistants take over, we won't go anywhere, we won't go anywhere. I think it's all about preparations. They have to go to the tutorials prepared better than I am going to give these questions to the students and if they discover some difficulty how will I tackle the question, but they just go there and give us questions and if we experience problems they say, no, we don't have to spoonfeed you. Guys, it's not like you are spoonfeeding us, we are trying our best. If they can take the questions, they know the questions, and prepare and verify and after that they give those questions to us and we try to see if we are able to do that, and then if we experience some problems, then they can help us. The reason to go to tutorials is for them to help us where we couldn't find answers.

S2: Myself I will attend the tutorials provided the lecturer is the one in charge because as for the students, students assistants, I know we are going there just to work hard to get those answers, they don't even give us hints. They are expecting answers from us. So they are not the right people to help us, not because they don't want to, but because they don't understand some of the concepts. They don't have that knowledge.

I: Can you describe your tutorials?

S10: In physics, there is no tutorial session.

S12: They use to give us tutorial, and then.

S10: They just give us tutorials, and we have to answer them, and if the lecturer feels like he can give us solutions for 1, 2, 3, then he will give us. Those others we do it ourselves, then we go and ask the lecturer.

S12: Ja, I think at tutorial, they just give us tutorial and then we go through that tutorial, if we come across something very difficult, we can go and consult the lecturer and then some of the tutorial they can treat with us, with us.

Lecturer L4 from the same institution as students S2 and S3 said the tutor and himself run tutorials in Foundation Physics that can last two to three hours. During that period they try to help all students individually. However, in Physics I tutors spend 90 minutes struggling to solve a single problem for the students.

In one of the institutions, the Foundation group indicated that tutorials do not form part of Physics I. If students have problems relating to a section taught in class, they have to visit the lecturer concerned. At this institution, tutorial sessions do not have a rigid slot on the time-table as indicated by Foundation Physics lecturer L3 below.

L3: ...There will be time wherein we will notify students in class that the following lecture will be tutorials based may be on what we were discussing the previous day or previous week.

From the responses of the non-Foundation groups, it is clear that tutorials are run in a similar pattern in all but one institution. In this institution (Institution 2), students are given what they call tutorial problems even though there are no tutors and tutorial sessions:

I: Can you describe the tutorials, your tutorials?

S13: Here we are just given tutorial questions. We don't have a particular session where we meet as students and tutor. We are just given tutorials at lecture and then you go and answer them.

I: Do you have tutors?

S14: No.

I: You don't have them?

S14: No.

I: Who helps you when you are dealing with tutorials?

S13: We answer the questions ourselves and then we go and ask if we don't understand to the lecturer straight to the lecturer.

I: OK. Do you find that to be easy?

S13: No, no, there should be a class where we discuss as students may be with other students who are doing honours or third year.

I: Why do you say it's not easy?

S13: Ah, neh, all of us go and do the tutorials independently. For me I find all of my answers right and I won't know which one is wrong and I won't go to the lecturer.

I: OK. You don't have groups?

S 13 & 14: No.

I: You don't form groups on your own?

S 1: We do. (Laughter).

I: If you form a group, how many people will be there?

S14: Two.

S13: And we don't have formal groups here. Sometimes you may find yourself alone because people will go to a person who answers in the class and they will be around him (laughter) and if you are not known you will be left alone.

I: OK. So, they go according to how familiar you are in class?

S13: Ja, they know that this one answers, and then (laughter)

I: Can you describe your tutorials? What happens during the tutorials?

S21: In our side, we are also learning the leadership because sometimes our tutor will just let us calculate those problems on the board, then he just sits down and lead us, and discuss them and even if we don't know about them, is then that he can show us that we were missing something.

I: OK, are you going to practice the leadership skills somewhere?

S21: Ah, no, no, the way he is just giving us the chance, I mean, there is no need for some one to go somewhere, he is trying to make him taught that leadership. We are already taught we can just apply.

I: Are you going to apply it somewhere?

S21: Ja, we will, we will, even in holidays I was teaching the matriculants at home with the experience that I got here.

Other groups of non-Foundation students did have tutorial sessions and tutors were there to assist them. It's pleasing to find that some students not only learn how to solve physics problems during tutorial sessions, but they also learn some skills which they can apply in their communities as indicated by S21.

The Foundation group students from one of the institutions believe that tutorials are an effective way to learn physics, even though they think there should be some improvement.

I: Do you think that tutorials are an effective way for you to learn physics?

S2: A what?

I: Effective way for you to learn physics? Tutorials.

S1: Tutorials are important, are essential, we have to go to the tutorials but the way we do them here is a problem, because we sometimes come here and go back home without getting any answer from anyone, so if they can, they are good, they are good, they have to be done so that we can prosper in physics.

I: OK.

S2: I think they are good, tutorials, so it depends on who is in charge like, there are many, like tutorials of other subjects like math, applied math, those lecturers, our lecturers are the ones which I saw I benefit a lot from those even from the tutorials. So I think the same should also be done in physics.

All the non-Foundation students believed tutorials are an important section of physics. However there is a concern that most tutors come to the tutorials under-prepared. The students indicated that some tutors could not find the solutions of some of the tutorial questions. According to the students, tutorials are different from a lecture because they say the purpose of tutorials is not to teach but to help those who have questions.

I: Do you think that the tutorials are an effective way for you to learn physics?

S5: Ja, but sometimes I think they waste our time because they spend lot of time there and at the end we don't get the solutions sometimes. Yes, because sometimes the questions are even difficult for the assistants. (they laugh)

S7 : I think sometimes they go there unprepared.

I: Is there any aspect of the tutorials that you dislike or think is not effective for you?

S5: May be the tutor would write, may be for example question number 1, question number 2, one after the other without getting the solution for the first one, like I said, going to the tutorial not being prepared and then you end up not getting the solution for the first one, but we have got so many problems and don't even have solutions for them.

S6: I think it's more like they come up with problems and solve them, they don't come up with problems, and we solve them.

S19: When the tutor comes and gives us solutions. That's not nice. Sometimes, it differs from the tutors. We have different tutors. Some of them they just come give us solutions and go. And we are, and we actually have to go through those solutions being individuals to understand them ourselves. They are not actually helping.

Although some of the non-Foundation group students would attend tutorials not prepared, they did not like the tutors who did not prepare. Some tutors, as S6 and S19 indicated, solved problems for students rather than to guide them in solving them. The Foundation and non-Foundation groups from each institution had similar views about the tutorials.

5.12 Exercises, tests and exams

According to Foundation group student S3, students do not always fail tests and exams because they were not taught well, but because they sometimes are lazy. Students in the Foundation group found the questions asked in tests and exams to be challenging. They encouraged students to study for understanding not just rote memorization.

I: What is your reaction to the nature of exercises that you are given and tests and examination?

S3: We don't fail to answer not because we are not taught. We are taught, most of the things we are asked in the question papers they are being taught to us, so, the other thing is, OK, let me speak for myself, I am lazy.

S17: So it means when you study you must study for understanding, you cannot just cram because you won't be able to apply that when tackling the exercises, tests or exams.

Questions asked in the tests and exams in one of the institutions were not exactly what they had seen before. This allows students to learn for deeper understanding and not just memorizing without understanding.

I: What kinds of questions are asked in tests and exams?

S15: It's not exactly everything that we were taught in class. Then, it's like, I know in the last module, there was this question that said "what makes pie to be hot?" It's not what we were taught in class. Or "why is the sky blue?" is not what we were taught in class. We just have to know it, applying the physics concepts.

In the non-Foundation group, student S5 said that sometimes the questions asked were very unrealistic.

S5: I think sometimes they ask questions but the data is not realistic, so at the end we'll get an answer we cannot rely on, because it's something we did not expect, like may be they ask you

a question, in electricity. You find that the electric field is very large but the speed of that charge is very small and then you start to doubt your calculations.

There were no differences between Foundation and non-Foundation groups from all the institutions. Students from the same institution viewed exercises, tests and exams in a similar fashion.

5.13 Students' expectations and attitudes in Physics I

Most Foundation group students from Institution 1 expected Physics I to be difficult.

I: Before you registered Physics I what were your expectations of the course?

S2: I expected it to be tough, because physics is tough (laughing). Physics is not a child's play, no matter what the lecturer can say, physics is not a child's play, it's tough. Even if I get, like myself when I pass my math, I was doing applied math, mechanics part. So it was good, when I fail I'm so emotional. I hate failing, so, ja physics is tough, I expected it to be tough.

S1: I came to it with the view that I am going to do something which is hard to understand, not that difficult about how you understand it. So I came into physics knowing that it is really, really hard to understand and it needs efforts if you could focus, or if you work hard you can do it.

However a few students expected Physics I to be simple because Foundation Physics helped to bridge the gap between High school physics and university physics.

Most students, like S15 and S17 from Institution 3 believe they did not understand physics at school because of the absence of practicals.

S15: Ee! [yes!] We didn't, what I thought is OK, at high school I thought physics was a difficult subject. After going through the Foundation Year I thought may be I was not taught the right way because ahh.. truly speaking I started really to understand physics. And now I think, ah, it's just the general subject.

I: And what made you not to understand physics at school?

S17: We were not doing practicals for one, and I think may be the style of teaching was the way that made us not to understand.

Lecturer L2's comment about the importance of Foundation Physics supports what student S15 indicated above.

I: In general, how well do you think Foundation students do when they go to Physics I?

L2: When they go to Physics I, according to the study that was conducted at [Foundation], the study was tracing the [Foundation] students throughout their degree programme. They do much, much better than the students that go directly into the first year.

The non-Foundation group, as in the case of some of the Foundation group expected Physics I to be difficult as indicated by the comments below.

S21: When I came I was thinking that it was going to be something very much different from high school. And then when I came here I just realized that they are building on top of what we are learning, then it's becoming more practical. And I even understand the things that I didn't understand at high school.

S22: I expected it to be more difficult and when we have to attend, and that's when I realized that it's not difficult.

S24: Physics, OK, I think, as I have said I thought OK, before anybody told me anything I told myself, physics is gonna be challenging. Then I have to prepare myself to be strong and face it.

S25: 'Nna' [myself], ah, I was expecting some, my expectation about this course, I expected, eh, something difficult because of in Matric I found physics being a difficult course to me and may be is because of the way the teachers were presenting it. The teachers were not engaging us in the teaching sessions. Therefore I just found it very difficult, and boring so to say, and it's what I expected here, only to find that ah, I was wrong, it was a different course, and I just had to register because of I loved it so much.

According to their responses, most Foundation group students indicated that one thing they liked most in Physics I was practicals. This is indicated by the following responses by students from one focus group.

I: What are the things you like most in physics?

S12: 'Nna' [me], I like to do practicals, because it's something that it needs my mind to understand what happened in physics and in life. Because to do practical, I think it is better.

S11: Me, I like, I like doing things practically, 'Nna' [me] I don't like theory.

I: Do you think you need the theory?

S11: Myself, myself, 'nna' [me] I need the theory and practicals.

S10: If I can just do practicals, it's fine.

However, this was not the case with the non-Foundation group students. These students never mentioned practicals as one of the things they liked in Physics I.

Students' attitude to Physics I can be influenced by the manner they were taught at school. Students who had poor school physical science background would likely respond in a way that S2 responded below.

I: What are the things that you do not like about physics?

S2: The manner we were taught physics and the, the, the attitude our teachers cultivated on us towards physics. It is more of our mind; the perception we have on physics is what I dislike in physics. More, so when told that physics is difficult! Is difficult! So with that mind, aih, we are toughening it. I think the mentality, the mental part.

Amongst the things that some Foundation group students hated are graphs and copying notes as indicated below by students from one of the focus groups.

I: What are the things that you do not like in physics?

S12: Graphs, I think graphs are difficult because sometimes you can't understand. They say it is proportional to what, what, and inversely proportional.

S10: Things which I don't like in physics, just that thing and of writing notes and giving us examples without explaining a lot, ja I don't like it, because I can't just understand by writing notes without some explanations.

The non-Foundation students from one of the institutions where students were free to discuss amongst themselves with the lecturer indicated that they did not like discussion questions in the tests and exams.

I: What are the things that you do not like in physics?

S24: In physics? OK, I have to be straight in this one because for me I hate discussion questions (they laugh), those, I hate, I know that they are very challenging for me, but I hate them (they laugh).

S25: Ja, it's the same thing, 'le nna' I hate this discussion questions. (they all laugh).

I: Why do you hate discussion questions?

S25: I think it's because of what, the discussion questions are using, or consuming lot of our brains. You have to think a lot when it's coming there. It's unlike calculations, calculation you are using the formulas and equations, therefore you are just applying what is, 'kuri' [it's like] you are just doing the calculation part of it, and it becomes more simple than discussion questions, because physics is very much broad, sometimes you can find that the discussion question in your head or in your mind you can have more than three different questions eh, eh, eh based on three different theories, therefore it's where it becomes difficult.

S24: OK, I'll say, OK, for me I have to be straight sir, those things that challenge me I hate them, I hate things because they challenge me mentally. I want to be like good in everything and when they challenge me I tell myself no, I'm not good enough, I don't have to write these things, no, I don't want them but I want challenge at the same time. If I don't have challenge I say no, what am I doing here?

S26: Mine, I hate it because I'm not good in explaining.

While some Foundation group students hated graphs, they surprisingly liked practicals. This does not make sense because most practicals require students to interpret results in the form of graphs. Non-Foundation group students never indicated whether they liked or disliked practicals. Non-Foundation students from one of the institutions hated discussion questions. Surprisingly, the same non-Foundation students enjoyed class discussions. Even though lecturers might include discussions in their teaching, students might still be trapped in the way they used to learn at high school. However, those students who did Foundation Physics might feel comfortable with discussion questions. Lecturer L1 confirmed that it is not only the non-Foundation students who hate discussion questions, but those who were still enrolled for Foundation Physics as well.

L1: ...What I have observed from our students is that they don't like the reasoning type of questions. So they are more inclined to calculations more than the reasoning questions. So in answering these questions, some of the students might do well in the questions and some of the students will still have problems in these questions.

Lecturer L1 recommended that discussion questions should be included in every assessment given to students.

One of the concerns is that some student assistants were not competent enough on their job specifications.

The best option is that whatever written exercise, each written exercise that we give should have these questions irrespective of whether they like it or not. Then this is how physics is learnt, because we are not only looking [at] calculations. Whatever calculation is been done, is only to know the use of formulas, but we need the understanding of the concepts and the only way we can test whether students understand the concept is to include the theory part, at least 20, 30 percent of the questions. Whatever question paper, it could tutorial, it could be test, it could be classwork, it should consist of the theory part. Otherwise if they are just going to make calculations without actually finding out whether they understand in terms of the theory part they won't be able to know physics.

5.14 Acquired skills

Some Foundation group students have acquired laboratory equipment manipulation skills. These students also learned to be independent and they acquired report-writing skills as indicated by the responses from one focus group below. The skills acquired in the laboratory are not only useful in Physics I, but can be utilized somewhere in the students' future professional lives as indicated by S15 below. The laboratory skills acquired by the non-Foundation group students are in by no way different from those acquired by the Foundation group. This is indicated by the comments made by the two non-Foundation group students S13 and S25 below.

I: What are the skills that you acquired in the laboratory?

S1: Hhh, skills.

I: That you gathered, the skills that you gathered.

S1: I did not know how to connect an electric circuit, now I know how to do it. The other thing it helped me when coming to, to, to taking what I know and then putting it in practical. I, I benefited a lot from that.

S2: Ja, just working with the apparatus, so equipment and a mere working on those things are a skill I learned. Handling that lab equipment.

S3: Knowing how to connect negative charge and negative [terminal], is something that I gained that I didn't learn in class.

S15: Ee [yes], getting used to, to like apparatus. It's not only here where we will be using those apparatus, even if we are working like in laboratories or companies, we will be using such, such (S17: similar apparatus) apparatus. Then if we get used to them when we get there

we just perform. Taking down readings from the apparatus. It's not always, it's not accurate, it's not always accurate. We just have to like taking quite a number of readings, comparing them, may be take others.

I: What are the skills you acquired in the laboratory?

S13: The use of equipment and the way we should operate them and the way we should handle them.

S25: 'Nna' [me], I have acquired using the instruments with my own hands.

5.15 Conceptual understanding

The Foundation group students said they liked learning concepts. To show that they understood concepts, they also gave some examples of how one can explain them to people outside the science field. Most non-Foundation students like S19 and S22 below, indicated that they like deep learning of concepts more than memorizing without deep understanding.

I: How interested are you in learning concepts like Force? By concepts I mean anything which relates, like force. The question is how interested are you in learning, which means in understanding, you don't just, you are not just learning, but with understanding. How interested are you in learning those concepts?

S1:... So physics can say if I'm sitting down I'm exerting [a force] on a chair and the chair is exerting force on me. And some people they don't know that and we know that. And if we throw something up we know why it is coming down. You'll hear somebody saying "what goes up comes down" but not knowing how, so we know what brings that thing up, when you throw something up what brings it down.

S2: I'm interested in learning and understanding the concept because a very detailed knowledge and understanding enables me to implement the information or, ja to implement. If I understand something I'll be able to apply that. So understanding of concepts, I think it's important.

S1: And knowing that if you are somewhere, things are not happening like if I'm, I'm, I'm near the sea and I'm in the desert, some of the things that I do won't be, things won't be the same like eh, eh, eh, somewhere they read temperature in Fahrenheit and we read temperature in degrees. It's something that you, you, you, OK, 'nna' [me] I'm thrilled because I know things that some of the people don't know. It's what I like about physics, it teaches me things which are secret to some of the people who are not doing physics.

I: How interested are you in learning concepts, like force? OK what I want to know from you is whether you as students you like to understand concepts or want to memorize them without understanding.

S19: We like understanding because you don't forget, you get more interested and you get to actually know them, but when you memorize it's something else, it's just not clear in the brain.

S22: After a while you won't be knowing whatever you have to know, so understanding is the best thing.

Foundation group students from two focus groups used many strategies to learn concepts, amongst which memorizing is one of them. These group of students

admitted that they use memorizing especially when they are preparing for examination under pressure. Amongst the strategies used by the non-Foundation group to learn concepts are making use of the library, abstract manipulation of concepts, and reading the journals and magazines as indicated below by the responses from two focus groups.

I: What strategies do you use to learn concepts? Or how do you learn concepts?

S2: I, I, as I mentioned first, I read from textbooks because they understand, actually explain things I basically the same way but basically the thing is the same but different ways. I rely on using different textbooks.

S4: For me it is easier to read textbooks before, before we attend a class, because when you attend a class without consulting textbooks it makes things difficult to understand.

S1: To add on that, going through different textbooks, and proving things to yourself so that you cannot forget them easily and to, to, to concentrate a lot in what you are doing or what has been said to you or what are you discovering.

I: What strategies do you use to learn concepts?

S15: It's not always the case where you have like just go through the book. It's like put, if something is presented to you, put it, put it in your own way so that you can like understand it. It's not always the case where you just have to memorize what is in the book or what is written. You just have to take the key concepts and put them, put them together in your way.

I: OK, when do you as students memorize?

S17: You know, (laughing), as students we like to learn under pressure, so (laughing).

S15: Even writing exams, if like today we are having two exams, and I know OK, this portion I can easily memorize, this one it needs understanding, ja under pressure. Ja, this one I'm going to write, go through it during the last two hours, I know that I can take it. And even if it comes then I'll get it.

I: What strategies do you use to learn concepts like force?

S19: 'Nna' [me] I like reading about them at the library sometimes. Read specific book for specific concepts. You need to actually read further and further.

S21: I sometime convert a concept into formulas. What I don't like is to read from the books. And if they are talking about something that is happening then I prefer to learn it only my own way. That I will understand. But if they ask I will explain the way they taught me.

S13: I study, I study books. Then, and read newspapers, some of the physics journals, science journals and study all of them.

5.16 Students' confidence

The Foundation group student S2 was most motivated to do Physics because there was a need to do something challenging while S23 said that he enjoyed physics at high school. Surprisingly, not even a single student mentioned Foundation Physics as one of the things that motivated them to do Physics.

I: What motivated you to do physics?

S2: I wanted to do something very valuable and tough. I always tell myself that if something is tough I need to be tough also. So that's what I wanted to do, but I'm capable of doing it, like let me put it this way, to be regarded as a champ, I need to compete with the champ. So to

measure my mental capabilities I decided to follow physics, to see how far, how, how high is my IQ.

S23: I have always enjoyed physical science in high school, so that's what motivated me to do physics.

The non-Foundation group of students gave different answers to what motivated them to do Physics. Some students were doing Physics because they were required by the faculty rules to do it, it's not because they like it. However, amongst this group of students there were those who had the love of Physics. One of the students indicated that he was motivated by his brother who was a Physical Science teacher. Another student indicated that even after being told that Physics is difficult, he felt he needed to do it because if it was not challenging he would relax and fail the examination.

I: What motivated you to do physics?

S5: I wanted to do mechanics that's all (laughter).

S7: I am only doing physics because I have to do it, but when I came to tertiary I expected to do electronics. So, I actually was not aware that I'd be doing physics. I am doing physics only because I'm supposed to do it

S13: I have got a great love of science. Then I know physics is the right way to go so if you want to be a scientist or if you want to do something on your own, discover things. Ja then I have been very much fascinated with physics, like seeing the things going to the space and satellites around the earth, nuclear activity, ja all those things.

S20: Myself, my brother was a physical science teacher, so he motivated me to go further with that stream of physics...

S24: I'll say for me it was like the fact that I have to fear eh, to face my fear. I was like I want to be strong now I don't have the pressure from my parents. If I can go for something, which is easy, I will relax and probably fail. When I go for something which is challenging, it will need me to concentrate more and consume my time studying so that I can, OK, face my studies, then I can easily pass. The fact that I'm interested in some medical researches in the future, I find that OK, what do I need in the future, I find that OK, what do I need first? I say OK, physics, when I have physics I know that I can easily perform my experiments.

In general, students do not like to ask questions in class. In the Foundation group, only students from one institution indicated that they ask questions in class. Most of the students in the non-Foundation group indicated that they do not ask questions in class. The reason these students are not asking questions in class is because they are shy. However, students from two institutions indicated that they do ask questions with the aim of understanding and to correct the lecturer where necessary.

Foundation group comments

I: How often do you ask questions in class?

S2: (laughing) There is no time (all laugh), there is no time, how can you ask eeh, not that I'm shy, I know myself I'm not shy, but I don't think it is good to ask a question in class. The condition is not good, we are many and most of the time, time doesn't allow us to do that. We are only allowed to ask "what time it is", in fact we have more time to ask during tutorials not during lectures.

S18: Only when we are not clear or we don't understand something then a student can ask a question.

S17: And when he may be just explained how that thing works and we say why that thing works like that. Is there any other way that thing works?

S23: I don't ask questions in class.

I: And why?

S23: Most of the time if I, because I think I understand the most. Like if he is teaching a thing right now, I listen and then not think it over in class, and I think I understand it then.

Non-Foundation group comments

I: How often do you ask questions in class?

S5,S6,S7,S8: (Laughter) No, no, no,

I: And why? Why are you not asking questions?

S7: Sometimes is because our questions are answered and sometimes is because we are too shy.

S6: And we are shy.

S13: Everyday.

I: Alright. So, you are bold enough?

S13: Ja. (Laughter)

S19: In class, almost everytime, we ask questions everytime, ja, so, and we have students, they are very, I don't know, they like arguing, so we argue a lot and we actually ask the lecturer, what do you mean about this, even if this, you know, the way I understand this and that and that, he is telling me 'kuri' this how are we differing.

S20: Actually if I'm not understanding I will raise my hand and say here I don't understand and maybe if you can repeat this one.

S19: Or may be when you realize that 'mara' [but] the lecturer is wrong there, according to my knowledge that's not the case, you actually tell him that "sir, right there you are not going well". We actually correct the lecturer.

S20: Maybe he wrote negative instead of positive. May be you can say "Sir, I know in your mind is positive, but your hand wrote negative". So, he can write positive.

I: So, you do it with the purpose of correction?

S20: Ja.

S19: Not only with the purpose of correction, sometimes, you know, to interact.

S20: 'Kuri' [just] to be clarified. There are some lecturers, may be because they have higher qualifications they don't want to be attacked in class. May be if you can go to his office and tell him what about this. You can do this that way. He can understand because some in class they can tell you, no, I made research of this course you can't, you can see it's because of those may be six hundred students, he can't allow to be corrected by a student, but in his office he can understand you and he'll apply this thing, you will see him next time applying in his class.

S24: Ah, this is like everyday, like we have to like asking problems everyday.

Students from both the Foundation group and the non-Foundation group said they felt free to ask questions in the laboratory than in the lecture.

Foundation group comments

I: What about during practicals?

S4: In practicals we are free to ask questions because at that time, like that situation is not similar when I'm with a lecturer in the tutorial. At that time you feel free! I don't know what makes me feel free rather than when I'm in the crowd.

I: What about during practicals? How often do you ask questions?

S15: Mmm! Most of the time the questions are asked when there will be like briefing just before the experiment. They will tell you that ee! Now I'm done like briefing you. Is there anyone with a question? And after he answers the question, then we go to places where we will start performing the experiment.

S23: Practical, we ask questions a lot of times, 'cause maybe we have problem with the apparatus or the way we have to do the practicals. We have to ask questions all the time.

Non-Foundation group comments

I: What about during practicals?

S6: During practicals I ask.

S7: During practicals I think the atmosphere is friendlier.

S5: In practicals we debate a lot, we make lot of noise.

S6: Everyone wants to explain the way they heard, and you call the assistant to help.

S7: Each and everyone don't want to agree with these two concepts and understandings, and no one, neither of these two would like to give in. (all laugh)

S13: Ja, during practicals if I don't understand I ask for an assistant.

S24: Ah, it's also the case, we ask questions everyday, like when they, they try to demonstrate those, those things you have to ask questions, like OK, this works like this, what if it's done like this, then they'll explain. You ask other questions, they ask other questions, then when you perform the experiment you find problems you call them you ask other questions. I do this, this gets like this, then I don't know, is this appropriate? They say no, this is not appropriate. You find the solution and you say OK you will know now, this is not right then I have to create a solution around that.

S26: Mine it depends to the experiment that we are doing. If I find that it's difficult, it's then that I can ask a question but there are other experiments where you can't need another explanation.

S25: 'Nna' [Myself] I just ask what I don't understand concerning a practical or that experiment.

5.17 Physics workload

While some Foundation group students were up to date with their work because they didn't wait until it piled up, S4 was not happy with the way he handled the workload in Physics because he only started preparing when the test was approaching. This student was an exception. Most Foundation students kept up to date with their work. The non-Foundation students agree that there is a heavy workload in Physics and they indicated that they study a lot, and also visit the library.

Foundation student comment

I: How do you handle the workload in physics?

S4: Truly speaking, for my side 'hai', 'hai' [no, no], it is very difficult for me, because sometimes I find the way the work, I find myself doing it, may be in the last minutes, in the last minutes, yeah! And I don't cope when I do my work in the last minutes. I simply like to make the question a week before instead of making it in last minutes.

Non-Foundation group comments

I: How do you handle the workload in physics?

S19: The workload? We study a lot, we study, actually our course is, you know, is challenging, so it forces us to go through everything that we do in class at our own spare time. We don't actually have much of spare time; we spend it all on the books.

S19: Even at the library you'll find physics students. You know, we actually grouped ourselves, that's why people don't, some of them they don't like us, they say we are proud because we move, like going in groups. We group ourselves as physics students. So, they don't understand why we are in groups, we are discussing.

I: So, are you like a family?

S20: Ja.

5.18 The role of Foundation Physics in learning Physics I

According to Foundation group students, especially S15, S16 and S17 who are from one institution, there is a gap between high school and tertiary education, and Foundation Physics minimizes it. Foundation Physics helped students to cope with Physics I, because as S1 puts it, 60 to 70% of what was covered in Physics I was covered in Foundation Physics. However, not all the students saw Foundation Physics as an important instrument to prepare them for Physics I.

Foundation group comments

S15: ...and I think that Foundation Programme, was, 'kuri' [it's like] it gave me much motivation,

it really helped me in doing physics.

S16: And some of the things we did in Foundation Year, we are doing them now, but last year we

didn't do them in detail.

S17: It was sort of a bridge because there was a gap between high school and university. I noticed most of the students who come straight from Matric to university they always fail their first year because for others it's that freedom away from home and for others the learning is different. So, at least Foundation Year helps you really. It brings you up to the standard of university or may be of any tertiary institution.

I: In which ways do you think Foundation Physics helped you to cope with Physics I?

S1: Most of the things that I, I, I have done in Foundation, I can say I got basics from Foundation, and I am learning what I did in Foundation in detail. If I was from school and I came through physics I, I don't think I would be doing as much good as I'm doing now. It's, it's some of the things that I've done in my Matric are not done here, it's just 2% of that, but in Foundation we are doing almost 60-70% in this course, physics.

S2: Ja, I think eel, in Foundation is where the gap between the school and Bridging tertiary education is being minimized. So, because if the student is straight from school to tertiary education, it is very tough, it is very tough. The style of teaching at tertiary and there in school is very different. Most of the things are different, so it is very tough. There is a gap between matric and tertiary institution, so this bridging course helps to close the gap.

I: In which do you think Foundation, oh no, no, not Foundation, you don't call it Foundation here,

Bridging Physics helped you to cope with Physics I? How did Foundation Physics or Bridging Physics help you cope with Physics I?

S10: Myself I don't think it helped me because, like she said, it was very simple that Bridging in physics, it was very simple, and this one is very difficult, then when I discovered that this first year physics is very difficult I didn't see any necessity for doing physics.

S12: I think, I think bridging, that bridging physics it makes us to understand physics I because in Grade 12 there is no way, we didn't waves and length [wavelength], and then, but in, in that Bridging we were doing those things, wave and length, and even in Physics I there is wave and length.

S11: I don't see any necessity for it. It did not help me. The Foundation Physics was very different, 'cause now I'm doing thermodynamics.

S10: And this first year Physics we have to derive, the equations and in the Bridging they don't, they don't tell us about deriving. We just substitute numbers into formulas, substituting just that. But here we have to derive, ja, and some of the questions they just come telling us to derive what, what.

S12: Is all about deriving!

I: Derivations and calculations?

S 10 & 11: Derivations and calculations.

I: Now, which one do you prefer, between Bridging and Physics I?

S11: We are going to say we prefer the one for Foundation, it's just that, we have to, length at least length, and it, the thing is, they don't have to be the, the same. The thing is Bridging is bridging then Physics I, then you are going to Physics ii, and Physics II, and Physics II won't be the same as Physics I.

S17: It was sort of a bridge because there was a gap between high school and university. I noticed most of the students who come straight from Matric to university they always fail their first year because for others it's that freedom away from home and for others the learning style is different. So at least Foundation Year helps you really, it, it, it brings you up to the standard of university or may be of any tertiary institution.

S15: Ja, like getting used to the environment of this higher learning style, and I think that at Foundation Programme, was, 'kuri' it gave me much, much, much motivation, it really help me in doing physics.

S16: And some of the things we did in Foundation Year we, we are doing it now, but last year we didn't do them in details.

I: OK.

S17: And in Foundation Year, they teach you how to think about something, to be able to analyze a problem because before you just look at the problem and say it's difficult there is no way I will do it. So when you try it, you think around it, and play with the problem then you'll end up getting it.

S15: And the other way of like presenting our report, because the English at the Foundation Programme is not like the everyday English, it's Scientific English. We don't use the he's and she's. It really, eee! It's all about physics.

S23: I think it helped me, it explained a lot of what is in Physics I, not really detail that much, just explaining them, and then when you go into Physics I, you go into the details and you understand because you have the background of Foundation Physics.

5.19 Foundation Physics Lecturer Interviews

Foundation Physics lecturers (L1, L2, L3, and L4 from Institutions 1, 2, 3, and 4 respectively) were interviewed in order to get some insight into some questions that were not fully answered by the students during the focus group interviews. The lecturers' responses about Foundation Physics are discussed under each sub-heading.

Components that form Foundation Physics course

Lecturers (L1, L2, & L4) from three institutions indicated that their Foundation Physics courses consist of three main components, namely the practicals, the lecture section, and the tutorials. The practicals are done once per week for a period of three hours. There are five lectures per week in each of the three institutions. Each lecture period lasts in the region of 40 minutes to 50 minutes. In one of the institutions, there is no period that is allocated for tutorials. Sometimes tutorials are held during one of the five periods allocated for lectures. However in one of the three institutions, the tutorials have two separate periods each lasting 40 minutes and in lecturer L1's institution tutorial sessions can run for two hours or even three hours depending on student understanding. In the latter institution the tutors help students individually at some stage.

Lecturer L3 indicated that three sections, i.e. practicals, tutorials, and lectures make up Foundation Physics. However, all the three sections are integrated, as is indicated by the response of the particular lecturer (L3) below.

But in our case they are integrated, so we do them, we do a practical as it comes, and then we do a tutorial as it comes. It's not a separate thing, we don't have a period specifically for a practical. We don't have a period specifically for a practical. We don't have a period specifically for a lecture or a tutorial. They are integrated.

Teaching approach in Foundation Physics

When asked to describe the teaching approach in Foundation Physics, one lecturer (L2) indicated that the teaching approach differs from that for Physics I. Lecturer L1 indicated that "we are trying to complement the teaching that was learned at high school and some of the things that are being done at university. We kind of also act as a mentor to these students." Another lecturer (L3) described their teaching approach as:

... more of learner-centred in the sense that we, we don't give all the information to them, but we sort of give them questions that are forcing them to come with their own answers. ...When the student answers and we find that it's not correct, again we give another question, OK, until at the end the student comes up with the right answer. ...we don't say because it's wrong, this is the right answer,... The person has to come up with an answer, we just assist.

Lecturer L1 mentioned that they also use cooperative learning where they divide the students into groups for discussions. The students are randomly selected each time to form these groups. The tutor and the lecturer are always there to facilitate the discussions. According to Grayson (1997a), when students work together they have an opportunity to articulate and clarify their ideas with one another. This also informs them that “it is not only the authority figure that is the source of knowledge.”

Topics covered in Foundation Physics

The topics that are covered in Foundation Physics in the four institutions did not differ much. Lecturer L4 indicated that they cover mechanics, electricity and magnetism, modern physics, waves and acoustics, and optics.

The second lecturer (L3) indicated that the topics that they cover are measurement, energy and temperature, kinematics, dynamics, and electricity. The topics mentioned by lecturer L2 are Newton’s laws, momentum and its conservation, heat, electricity where they study Ohm’s law, optics, work, energy and power and all introductory sections in electricity. Lecturer L2 also indicated that

We do all the mechanics section, the one they do in matric and some few sections that they will be doing in their first year.

Lecturer 1 said that they cover vectors, conversions, Newton’s laws, momentum, and electricity and magnetism. He indicated that they do not cover thermodynamics and that they “... sit down and look at things that students need to understand ...” because mainly their “interest is to build their [students’] reasoning capacity and the concepts.” Their main aim is not to cover all the sections that will still be covered in Physics I, but to develop student understanding.

Other elements covered that are not physics

Lecturers L1 and L2 indicated that they refer students that are experiencing non-academic problems to guidance and counselling staff. Students who experience problems relating to other Foundation courses like Mathematics and English are according to lecturer L1 sent to the relevant Foundation course lecturers to get help.

Relationship between the content of Foundation Physics and the content of Physics I

According to lecturer L4 there seems to be some differences between the content of Foundation Physics and the content of Physics I.

The difference which I have observed in terms of Physics I and Foundation Physics, with Foundation Physics we are looking at pre-calculus and students are now introduced to calculus when they reach Physics I. But the background that have been developed in Foundation Physics makes most of our students to be able to do well in Physics I.

Lecturer L3 said that in Foundation Physics some of the topics like energy and temperature are done at a “lower level” and in Physics I “they go deeper now, it’s not on the surface like we do”. This indicates that the topics in Foundation Physics are not covered in great depth, but are meant to introduce students to the concepts.

Lecturer L2 further indicates that Foundation Physics covers some matric work and introductory sections of Physics I. This allows students to perform with ease when they go to Physics I.

Emphasis in Foundation Physics and emphasis in Physics I

Except for lecturer L2 who said that the emphasis in both Foundation Physics and Physics I focuses on both conceptual understanding and problem-solving, the other two lecturers were not sure about the emphasis of Physics I. The two lecturers (L4 & L3) responded to the question about the emphasis in Foundation Physics and Physics I as follows:

L4: Unfortunately I have not taught Physics I or attended any lecture or a period where Physics I is being conducted, so it’s difficult to say how the emphasis is.

L3: ...I’m just going to say what I think (laughing), remember, there are large number of students. I think most of the time they’ll [Physics I] do the lecture method. Because of the number and also because of you want to finish this bulk. So as for conceptual understanding, I don’t know whether they emphasize.

I: How many students do you have in Foundation Physics?

L3: In Foundation Physics we group them. At the moment they are 200. But then we group them in 33, 33, 33, there are others who are 34 in a group. So we would handle small groups, we don’t handle the big group.

According to lecturer L1, their Foundation Physics puts more emphasis on problem-solving skills, and conceptual understanding, whereas in their Physics I students are on their own without much help from the lecturers. The Physics I lecturers do not care much if students can memorize without understanding or not. Lecturer L1 indicated that in their Foundation Physics they divide their students into small discussion

groups. Before presenting a lesson, L1 asks his students how they would like to be taught the course. Students decide on how they want Foundation Physics to be presented to them. The democratization of the class makes most students feel at ease to challenge the lecturer's views. Lecturer L1 indicated that in Physics I the lecturers follow the traditional chalk-and-talk method. They don't help the students to understand the concepts. Physics I lecturers at lecturer L1's institution said that if they had the power "... they would recommend that all students registering for science should go through Science Foundation because it makes their work easier." This implies the Physics I lecturers at that institution prefer students from Foundation Physics because they are well-prepared.

Interaction between Foundation Physics and Physics I lecturers

Lecturer L4 said that lecturers in Foundation Physics and Physics I have a warm working relationship. When lecturer L4 needs help from Physics I lecturers the response is positive. However the relationship seems to be one-sided because lecturer L4 did not talk of himself helping the Physics I lecturers. The same is the case at lecturer L2's institution where the moderators for Foundation Physics are from the major course and they seek no course-related advice from Foundation Physics staff. In the case of lecturer L3, the interaction is both ways as indicated by the response below:

L3: ... we do interact, for example, myself, ...I was involved in one of the modules there [Physics I]. So I used to teach some one module, it lasted for about three months. And sometimes there are one or two who come [to Foundation Physics].

In Lecturer L1's institution Foundation Physics lecturers and Physics I lecturers interact especially when planning the syllabus and trying to look at "what we [Foundation Physics lecturers] are doing and what they [Physics I lecturers] are doing, because basically there has to be a synergy." However it should be noted that at lecturer L1's institution, as in the other three institutions input about how teaching of the courses should be improved is only directed to Foundation Physics and there are no discussions about how Physics I teaching should be improved. In the study done at one institution, Grayson (1997b) found that the Science Foundation programme had an effect on the mainstream teaching staff because they taught both mainstream courses and Science Foundation courses.

None of the Foundation Physics lecturers in this study ever indicated that the mainstream lecturers revised their “courses and instructional approaches in order to help mainstream students gain the kind of skills that they perceive that SFP [Science Foundation Programme] students possess (Grayson, 1997b).”

Performance of Foundation Physics students in Physics I

All three lecturers L2, L3, and L4 said that according to some previous statistics, Foundation Physics students do well in Physics I as compared to students coming from matric. This is further supported by lecturer L1 who said “Foundation students when they go to Physics I they do much better than those who are from, direct from high school.” He also indicated that 70 to 80 % of them pass Physics I on first attempt as compared to those who are coming from high school “...because some of them still have to adjust to the teaching approach at university, whereas those ones in Foundation they have already used to the system.” This is supported by a study done by Grayson (1997a) at one institution which showed “that 58% of students who take the Foundation Physics course and then take an introductory physics course [Physics I] pass it first time, as compared with roughly 50% of all other introductory physics. In another study, Grayson (1997b) indicated that for the students who were registered for a BSc degree 84% were able to proceed to their second year as compared with 24% for black students not connected with the programme. However, in Chapter 4, Foundation students were outperformed by the non-Foundation students in Physics I and in the FMCE test. This might be an indication that there are differences in teaching styles between Foundation Physics and Physics I, with the latter following a traditional lecture approach, also because of large numbers of students in class.

Performance of Foundation students in the gravitational acceleration questions

The four lecturers were asked how well they thought Foundation Physics students would do in the three questions about the acceleration of a coin moving upward, at the highest point, and moving downward. Their responses were as follows:

L4: What I have observed from our students is that they don't like reasoning type of questions. So they are more inclined to calculations more than the reasoning questions. So in answering these questions, some of the students might do well in the questions and some of the students will still have problems in these questions.

I: You indicated that your students do not like reasoning questions, what do you think should be done to improve, in order to make them like this kind of questions?

L4: The best option is that whatever written exercise, each written exercise that we give should have these questions irrespective of whether they like it or not. Then this is how physics is learnt, because we are not only looking calculations. Whatever calculation is been done, is only to know the use of formulas, but we need the understanding of the concepts and the only way we can test whether students understand the concept is to include the theory part, at least 20, 30 percent of the questions. Whatever question paper, it could tutorial, it could be test, it could be classwork, it should consist of the theory part. Otherwise if they are just going to make calculations without actually finding out whether they understand in terms of the theory part they won't be able to know physics.

L3: Not all of them [will get the correct answer], let me not say all of them. Not all of them, because even the group that I'm having now, you would find some who'll choose "A", but then there would be others who would say when it goes up it's, remember what the text-book is saying in matric. They would say when we go up, let's take up as positive and then down as negative. And then when we change it goes down, then, they'll say down is positive. So, I think they are, some of them that mentality is still there.

I: So, they are confused by different textbooks?

L3: By different textbooks because the textbook would say for upward motion let's choose this, which is not the same as the downward motion.

I: OK.

L3: Even though in our case we try to indicate to them that if, even if it goes up let up be positive and down be negative. When it goes down let's maintain the same thing, let's not change.

I: OK.

L3: Ee, ee [yes, yes], but you'd still find some who are saying this, OK, so you'd still find others who are saying when it goes up this is, because this is positive, then this one is going to be a different one. Mm, mm, mm [yes, yes, yes], but I would say some would choose "A" OK, and then the others I think they would choose, eeh, negative and then constant...

L3: At the highest point because the velocity is zero, then the acceleration would be zero, majority, not majority, some of them would still say that because in their mind acceleration is something like velocity.

I: Ja, it relates to velocity. If there is no velocity there is no acceleration.

L3: If there is no velocity how can we talk of acceleration, because there is no velocity? Which is something that we all try to rub, that when you talk of gravitational acceleration, it's always there, and it's always directed downwards.

I: Now in the process of rubbing whatever there,

L3: (laughter) Whatever is there?

I: Ja, what are, how do they react to that?

L3: Some, you remember, to rub something is difficult.

I: Ja.

L3: Ee [yes], you need to come up with the exercises, you need to come up with, when you go through the tutorial, ok, remember you talk of OK, they would say down is negative or down is positive.

I: Mm [yes].

L3: OK, then somewhere they say is zero, OK. Then it returns with a different sign, so which means somewhere, somewhere in their mind they would say there is a decrease.

I: OK.

L3: Ee, ee [yes, yes], because it's positive, zero, negative. OK, so in their mind somewhere they are saying it's positive but then decreasing, somehow it stops and then it becomes a negative.

I: And so it's like a number line?

L3: It's like a number line, ee, ee, ee [yes, yes, yes], so until you come up with this straight rail.

I: Mm.

L3: I think the straight rail helps because you show them that, Ok, the velocity is increasing, but then what happens to the slope, what happens to the inclination of this rail? Is it changing? No.

I: OK.

L3: Ee [yes], so that's when you introduce that concept that the inclination, what it's actually is it's showing us how the velocity changes with time, OK, and that is our acceleration.

I: OK.

L3: Because the inclination is the same, the acceleration is the same, I mean the velocity is the same even though the acceleration changes, I'm sorry even though the velocity increases.

I: Mm [yes].

L3: Mm, mm, mm [yes, yes, yes]. So even, even with the straight rail, remember, once you have the inclination then you do the steepest slope.

I: So, you'll increase the angle.

L3: Ee [yes], you'll increase the angle, OK, what happens to the inclination? It's not changing, is the steepest slope OK. Even when it goes along this we still talk of the constant inclination.

I: Mm [yes].

L3: OK, the rate at which the velocity changes would be constant, mm, mm [yes, yes].

I: OK.

L3: Some, some of them would see some light.

I: So with this rail that you are using, do you use it, so you would change the angles.

L3: We would change the angles.

I: until it's vertical.

L3: Until it's vertical.

I: OK.

L3: Mm, mm [yes, yes].

I: After you have done all these, how is the response of the students?

L3: Now you'd start seeing some change.

I: OK.

L3: Ee [yes], so when you go to tutorials you'd see some changes. Now they see it, OK, when I see the inclination I associate it with acceleration, mm, mm, mm [yes, yes, yes].

I: So the same will apply to the last question?

L3: The same will apply to the last one, mm, mm [yes, yes]. But otherwise when they come out of the programme they are really changed. And remember this students that we take are the lowest.

I: OK.

L2: They are the ones that would not have been accepted at a university, ee, ee [yes, yes], but then they would fight ee, ee [yes, yes] until they would then outshine the ones that come straight to the university.

L2: Well, do you mean the ones, questions 27 up to 29?

I: Yes, they are about a coin that has been thrown upwards, and then it reaches the highest point and then it goes down.

L2: Well, I think with this problem, they should be able to answer almost everything because under our mechanics section we do projectile motion and then the moment we, this is the projectile motion problem. And then they should be able to know that when you throw something up, when that something reaches its maximum height, the speed becomes zero, the final speed will be zero, and then the acceleration will be g , the acceleration due to gravity. And then when it comes, it depends whether is the projectile motion. We don't teach them the projectile motion in two dimensions. It is just projectile in one dimension, you throw something up it comes down at the very same point.

I: OK.

L2: But then, with this problem, I think they should be able to do it well, I mean to answer it well. I don't see any, because the theory about projectile motion has been taught, it's easy for them to follow, and they should be able to calculate them, the lowest point, the highest point, the maximum height reached, the projectile, the time for a projectile to reach its maximum height, the total time the projectile is in the air, all those problems we teach them in our foundation programme.

I: OK, What problems do you, just to, it's a follow-up to that question.

L2: Ja.

I: What problems do you experience when students come, especially problems relating to such motion of objects?

L2: No, it's about what I normally emphasize in this kind of problem is about direction. And then, one should be able to decide about the direction because the moment you don't choose a direction in projectile motion the way you'll be solving the problem I mean it will be very

complicated. You choose a direction first. If I'm saying that I'm throwing something up, if I'm taking the upwards direction to be positive, we should remember that g should have a negative sign because g is always acting downwards.

I: Ja.

L2: then in that case, otherwise if we want to take it the other way round, we should say OK, we are taking the downward direction to be negative, I mean to be positive, and then it means that the moment you take the downwards direction to be positive the value of g should take a positive sign and then your initial velocity that will be going up has to have a negative sign. So what I normally tell my students is that: decide about the direction because direction is very important when it comes to projectile motion. If you don't decide about the direction, when you apply your equations of motions, then it will be very difficult for you to decide whether the velocity in this case is positive or is negative. And then another thing that I normally try to emphasize is about the units. Because our students, that's why in our introductory chapter we talked about units and measurements. Our Foundation students, in physics if you write something without units is meaningless, because if you write for example, you write twenty, just 20 as a number you will ask yourself so many questions. That is twenty degrees, or twenty kelvin or twenty meters per second. You can ask so many things, but the moment you specify that this is twenty meters per second you know that maybe someone here was working out the speed or working the magnitude of speed, maybe divided displacement, distance by time and then he got that. Mostly the problems that we encounter with these students are about units, because they don't seem to understand it. That's why in our introductory, even to convert, I mean just to use the calculator, some even struggle to do that one.

I: OK.

L2: Use the calculator, how do we convert say for example, distance which is in centimeters to meters and those things, that's why in our introductory section we make sure that we teach those introductory section, units, and measurements.

I: OK.

L2: Because most of them their problem has to do with units and how to decide about the direction when it comes to this particular problem. That's why those are the things that we emphasize mostly.

Lecturer L1 indicated that many of the students would do much better in this kind of questions because he usually asks them questions structured in the same way. However, he indicated that when students come to Foundation Physics they have a lot of confusion about what the sign of upward motion and falling motion should be.

5.20 Summary

Students in the non-Foundation focus groups worked well in Grade 12 to attain good symbols that saw them admitted in Physics I. The Foundation group students went through Foundation Physics so that they could be accepted in Physics I.

Many Foundation and non-Foundation students from three institutions indicated that they would not take Physics as one of their majors. Some of these students indicated that they were not aware of the job opportunities for Physics, and others would like to major in other courses. However, almost all the students from one of the institutions said they would like to have Physics as one of the majors. Amongst the things that

influenced students to do Physics and ultimately do well in mechanics were the school teachers, Foundation Physics, lecturers and relatives. Students who indicated Foundation Physics as one of the factors that motivated them to do Physics also indicated intentions of taking Physics as a major subject.

Almost all the students in all groups expected Physics I to be difficult. Amongst the things that helped students to understand Physics I, were students' initiative towards studying, practicals, and tutorials. However, some students did not like the way that practicals and tutorials were run in their institutions. This is also supported by some of the lecturers who when interviewed indicated that Foundation students do not like discussion type of questions. However, lecturers indicated that these type of questions should be included as part of assessment. A few students also indicated that they liked lecturers that engaged them in classroom discussions. The FMCE presents word questions, which most students in this study did not like, and hence it might be right to say that that is why they performed poorly in the instrument as compared to their average performance in mechanics exam.

Foundation group students still expected lecturers to guide them throughout the Physics I course even after they had undergone the Foundation Physics course. Some non-Foundation group students also found lecturers to be not so helpful. There were no discussions in classes of the two institutions. In the few cases where there were discussions, students were afraid to participate because other students would laugh at them if they gave wrong answers.

The majority of the students (Foundation and non-Foundation groups) interviewed indicated that they liked practicals even though they never had practicals at school. Students from two institutions were not happy with the way practicals were run because their demonstrators came to the laboratory not fully prepared.

As in the case of practicals, tutorials were also not well run in the same two institutions. The students from the two other institutions were happy with the way their tutorials were run in their respective institutions. Foundation and non-Foundation students indicated that they felt free to ask questions and discuss in tutorial sessions because they said the setting was more informal as compared to a

lecture. Foundation students are more comfortable in the lab than the non-Foundation students because the former gained practical experience in Foundation Physics.

There were mixed feelings about Physics I. Most Foundation group students, even though they indicated that Foundation Physics laid a good base for future study in Physics, said that Physics I was taught differently from the way that Foundation Physics was taught. However, this study might not conclude that because they were taught differently, they therefore have to perform poorly in the FMCE. It is worth noting that all Foundation and non-Foundation groups covered similar syllabi for mechanics both in Foundation Physics and Physics I (see Tables 4.1 and 4.2). The Foundation and the non-Foundation group students from one of the institutions found Physics I to be very interesting, but others found physics to be a difficult and boring subject with few job opportunities.

Amongst the skills that the two groups acquired were handling of laboratory equipment, listening, and memorizing equations and formulae. However, some Foundation group students hated memorizing because they said, in Foundation Physics they were never taught to memorize formulae and derivations. They used to be given formulae.

When asked about the concepts they learned, few students mentioned gravity as one of them. Also, when they were asked to indicate what motivated them to do Physics, not even a single Foundation group student explicitly mentioned Foundation Physics but later they did indicate that it helped them in Physics I. Some Foundation group students had internal motivation to achieve. Some students registered for Physics I because they were required by the faculty rules to register it as one of the compulsory first-year courses, but they were not going to take it as one of the major subjects.

Two Foundation Physics lecturers didn't know at the time of the interview if there were differences in teaching approaches for Foundation Physics and Physics I. They said they were not sure what the teaching in Physics I is like, they could only guess that maybe they use the lecture method.

The lecturers in Foundation Physics and the Physics I do interact, however their relationship doesn't extend to a level where they could exchange information that could help connect Physics I and Foundation Physics.

The Foundation Physics lecturers said they expected Foundation Physics students to do better in Physics I as compared to students who come from matric. However this was not the case. Table 5.3 indicates some of the important points that were raised during the interviews:

Table 5.3 Issues that emerged from students' interviews

Section heading	Foundation students	Non-Foundation students
Grade 12 Physics background	Did not perform well in Grade 12 physical science	Performed well in Grade 12 physical science
What students aim to achieve in Physics	Student's career choice is influenced by the institution they are registered with and teaching style.	Student's career choice is influenced by the institution they are registered with and teaching style.
What students expected Physics I to be like	Expected Physics I to be difficult.	Expected Physics I to be difficult.
What helped students to understand Physics I	Did not cite practicals as helpful to their studies but were more comfortable asking questions during practicals	Some students cited practicals as helpful to them
Lecture section and lecturers	They benefited from the discussion in the class	They benefited from the discussion in the class
The effectiveness of the lecture section	Not effective	It's a student duty to supplement the lecture by reading.
Discussion in class	They ask questions in class.	Do not ask questions in class.
How do discussions in class help	It's easier to understand concepts through class	It's easier to understand concepts through class

students?	discussions.	discussions.
The practicals	Most of Foundation students enjoyed the laboratory work while the others did not	Some students indicated that they did not enjoy laboratory work because it was not run well.
Tutorials and tutors	Believed tutorials are an effective way to learn physics. Tutors are not well-prepared.	Believed tutorials are important. Tutors not well-prepared
Exercises, tests and exams	Students found exam and test questions challenging.	Students found exam and test questions challenging.
Students' expectations and attitudes in Physics I	Expected Physics I to be difficult. How they were taught at school influenced their attitudes towards Physics.	Expected Physics I to be difficult. How they were taught at school influenced their attitudes towards Physics.
Acquired skills	Acquired laboratory skills at university	Acquired laboratory skills at university
Conceptual understanding	Disliked memorising formulae in the Physics I course	Did not show attitude to formulae or derivations
Students' confidence	Most students are shy to ask questions in class	Most students are shy to ask questions in class
Physics workload	Handle the workload well by studying in advance	Handle the workload well by studying and visiting the library
The role of Foundation Physics in leaning Physics I	Foundation Physics bridges the gap between high school and tertiary Physics	

Foundation students performed poorly in Grade 12 physical science and non-Foundation students performed well in the same subject. Non-Foundation students did not show any attitude towards memorization of formulae, whereas Foundation students did not like memorizing without understanding. Foundation students however indicated that they prefer memorizing when preparing for examination or

test. All Foundation and non-Foundation students benefited from discussions. The differences in the two groups are not surprising because Foundation students might have been taught differently in Foundation Physics.

Chapter 6

Conclusions

6.1 Introduction

This chapter answers the research questions and discusses the implications of the main findings that were explored in the study. The limitations of this study are also discussed. The chapter concludes by giving some recommendations for further research.

6.2 Research questions

What influence does Foundation Physics have on students' performance in Physics I?

The FMCE results show that Foundation students performed better than the non-Foundation students in all but two groups of questions. The Foundation students could not be accepted to do Physics I because their Grade 12 Physical Science symbols were low. Their better performance in the FMCE, a multiple choice instrument, indicates that Foundation Physics helped them to perform better than the non-Foundation group, who were admitted to Physics I with good Grade 12 symbols.

Although the Foundation group did not perform exceptionally well in the mechanics module, they performed on par with their non-Foundation counterparts as indicated in Table 4.16. This indicates that Foundation Physics brings the Foundation students to the same level as the non-Foundation students in terms of their mechanics module.

In what ways do the knowledge and skills of students who have been through a Foundation Physics course differ from other Physics I students?

Foundation group hated memorizing equations, something they were required to do in Physics I, because they say it differs from the way they were taught in Foundation Physics. Their poor performance in mechanics, one of the modules offered in Physics I may be attributed to their lack of memorizing skill. Since non-Foundation students'

performances were similar to those for Foundation students, this research also concludes that these students also struggle to memorise. However, the researcher would like to point out that not all institutions offered assessment that required students to memorise. Memorising is, according to Woolnough (2000), dull and abstract and makes students dislike physics. McDermott (cited in Crouch *et al.*, 2004) indicates that most students learn easily from instruction that actively engages rather than from traditional methods that are passive. Thus it seems that the teaching style used in Foundation is preferable to the one used in Physics I.

There were some Foundation students from Institution 2 who indicated that the way Foundation Physics mechanics was taught and assessed was different from the way Physics I mechanics was taught and assessed. These students pointed out that there were a lot of derivations and as such they would memorize without understanding. This is supported by Table 3.1 which shows Institution 2 asking derivation and calculation questions contributing 41% and 59% towards the final examination mark respectively without asking any conceptual questions. Institution 3, although they asked calculation questions contributing 63% towards the final examination mark, their questions were spread among the different types of questions, with 20% made up of conceptual or discussion questions. At Institution 4 the questions were also widely spread among four groups of questions, with 45% made up of calculation questions.

It can be concluded that Foundation Physics equips students with skills of answering conceptual questions. This seems to be lacking in Physics I where students are expected to memorize.

6.3 Summary of the main findings

On the basis of Tables 4.1 and 4.2 it is difficult to tell whether there would be differences in students' performances in Physics I mechanics module. Both the Foundation group and the non-Foundation group performed poorly in the FMCE test. However, the Foundation group performed better than the non-Foundation group in the FMCE questions as seen in Table 4.16 and Figure 4.14 (k). Even after the individual questions were classified according to categories, the Foundation group

still managed to perform significantly better than the non-Foundation group in the in most of the questions.

The Foundation Physics lecturer interviews revealed that there is little interaction between Foundation Physics staff and the Physics I staff. When they interact, they only discuss about Foundation Physics and not Physics I.

Many students that were interviewed in both Foundation and non-Foundation focus groups indicated that they would not take Physics as one of their majors because they said jobs are scarce. Other students indicated that they would like to major in other subjects. The few students who showed interest in majoring in physics said they were motivated by school teachers, Foundation Physics, and relatives.

Unlike non-Foundation students, Foundation students still expected lecturers to monitor and help them in the Physics I course. Non-Foundation students used other resources such as the library to supplement the lecture. Most Foundation and non-Foundation students felt more at ease to ask questions in practicals and tutorials than in a lecture. Some were afraid to ask questions in class because they said they could be given a nick-name after a wrong answer.

6.4 Limitations of the study

Although the study managed to evaluate the importance of Foundation Physics, it could not look at all the South African institutions. This was so partly because of lack of funds and that some institutions were not willing to participate in the study. The absence of a pre-test prevented the researcher from looking at students' gains. If pre-test and post-test were conducted, the research would be able to indicate how much students improved during the course as opposed to what they achieved in the end. Although the research was partly funded by the researcher's employer, the researcher used his own funds to conduct the study. The mechanics tests at different institutions were not standardized (see Appendix E) but served the purpose of comparing the Foundation and non-Foundation students.

6.5 Recommendations for further research

The researcher recommends that Foundation Physics and Physics I staff should communicate about how those two courses are taught at their own institutions. This could help in resolving the differences between the teaching styles in the two courses. Such differences affect students' learning.

Physics I should ask more conceptual questions in tests and examinations to develop students' conceptual understanding. This will also prevent students from memorizing without understanding. Further research should investigate how the interaction between Foundation Physics and Physics I staff members can be strengthened so that the two courses do not work as disjoint entities. This is crucial to the success of the FP Program and fits with much of the analysis in the thesis. The research could also benefit from pre and post testing using the FMCE at different instances – such as before and after FP, and before Physics I.

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Appendices

Appendix A: Physics I Student Interview Protocol

Background

1. Tell me about your preparation for Physics I.
2. Tell me a little about ideas you have for a major, or possible plans for your future professional life.

Physics I

3. What were your first impressions of mechanics module? [Probe for whether or not they were surprised or distressed by the presentation of the module.]
4. If you were to specify one thing that helped you understand mechanics, what would it be? Why?

Lecture-related questions

5. Can you describe the lecture section of your class? What does the lecturer do, what do you do?
6. (a) Do you think that your lecture section is an effective way for you to learn physics? Please explain.
(b) Is there any aspect of the lecture section that you particularly like or think is particularly effective for you? Can you explain and give an example?
(c) Is there any aspect of the lecture section that you particularly dislike or think is not effective for you? Can you explain and give an example?
7. Tell me what you think about the participation element of the lectures: when your lecturer asks you to either raise your hand and answer a question or discuss the question with your neighbour.
(a) How, if at all, do they help you learn physics?
(b) Are there any other benefits or detriments to engaging in this activity?

Practicals

8. Can you describe the practical session of your Physics I.
9. What, if anything, are you learning? [Probe for lab technique, concepts, etc.]

10. Do you think the practical session is an effective way for you to learn physics?
Please explain.
11. How different are practicals presented in Physics I compared to the physics you did before?
12. Is there any aspect of the practicals that you particularly like or think is particularly effective for you? Can you explain and give an example?
13. Is there any aspect of the lab section that you particularly dislike or think is not effective for you? Can you explain and give an example?
14. Can you describe the practicals? [Probe from cookbook versus inquiry-based.]
15. Is it different from the way you use to do practicals? How different?

Tutorials

16. Can you describe your tutorials? What typically happens during tutorials?
17. Do you think that the tutorials are an effective way for you to learn physics?
Please explain.
18. Is there any aspect of the tutorials that you particularly like or think is particularly effective for you? Can you explain and give an example?
19. Is there any aspect of the tutorials that you particularly dislike or think is not effective for you? Can you explain and give an example?

Topic-oriented Approach

20. What is your reaction to the nature of the quizzes, problem sets and exams?
Integrated lab reports? [Probe for their reaction to the shift from doing calculation-based problems to writing out their answers in essay form and addressing concepts.]

Expectations

21. Before you registered for Physics I, what were your expectations about the course?
22. Did you get what you expected?

Attitudes

23. How did you find physics?
24. What are the things you liked most in physics?
25. What are the things you do not like in physics?

Skills

- 26. What are the skills you acquired in the laboratory?
- 27. And in class?

Understanding concepts

- 28. How interested are you in learning concepts, like force [Probe to know whether students understand concepts or just plugging numbers into equations].
- 29. Name some of the concepts you learned.
- 30. What strategies do you use to learn concepts?
- 31. Do you like detailed learning of concepts or memorizing equations and formulae? Why?
- 32. Under which conditions do you learn best? Tutorials or lecture? Explain.

Confidence

- 33. What motivated you to do physics?
- 34. What do you do if you need assistance in class or laboratory?
- 35. How often do you ask questions in class?
- 36. What about during practicals?
- 37. In the process of asking questions, what do you learn?

Coping with the load

- 38. How do you handle the workload in physics? [Probe to understand how students cope with workload in physics]
- 39. Do other courses interfere in your understanding of physics? How do they interfere?
- 40. Do you think you need to do other courses to understand physics better?

Roles

- 41. (a) How important are the tutors?
 - (b) The lecturer?
 - (c) Other students?

General Questions

- 42. Has taking this course changed the way you think about physics?

43. Is there anything else that you can tell me to help understand your experience in this class?

Foundation physics (only asked to students who did Foundation Physics)

44. How did Foundation Physics help you?

45. Do you have any questions for me?

Thank you for your time, and I wish you all the best for your future.

Appendix B: Foundation Physics Lecturer Interview Protocol

The structure of the course

1. What are the components that form Foundation Physics?
2. How many hours does each component take?
3. How would you describe the teaching approach in Foundation Physics?

Course content

4. What topics do you cover in Foundation Physics (also ask for a syllabus copy)?
5. Are there any other elements that you cover that are not physics (to develop certain skills)?

Relationship between Foundation Physics and Physics I

6. What is the relationship between the content of Foundation Physics and the content of Physics I?
7. How does the emphasis in Foundation Physics course compare to the emphasis in Physics I (i.e. problem solving, conceptual understanding)?
8. How does the teaching approach in Foundation Physics compare to the teaching approach in Physics I?
9. How much interaction is there between the lecturers in the two courses (In what ways do you interact)?
10. In general, how well do you think Foundation students do when they go to Physics I?

Some conceptual questions

11. How well would you expect your students to do in the following questions (Questions in the FMCE questionnaire)?

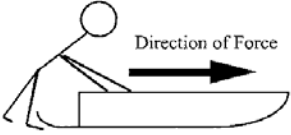

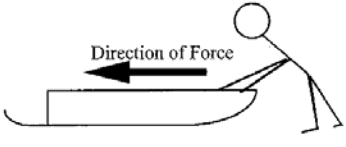
Appendix C: The FMCE questionnaire

FORCE AND MOTION CONCEPTUAL EVALUATION

Directions: Answer questions 1-47 in spaces on the answer sheet. Be sure your name is on the answer sheet. Answer question 46a also on the answer sheet. Hand in the questions and the answer sheet.

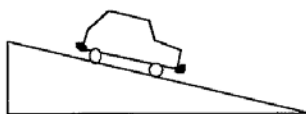
A sled on ice moves in the ways described in questions 1-7 below. *Friction is so small that it can be ignored.* A person wearing spiked shoes standing on the ice can apply a force to the sled and push it along the ice. Choose the one force (A through G) which would **keep the sled moving** as described in each statement below.

You may use a choice more than once or not at all but choose only one answer for each blank. If you think that none is correct, answer choice J.

	<p>A. The force is toward the right and is increasing in strength (magnitude).</p> <p>B. The force is toward the right and is of constant strength (magnitude).</p> <p>C. The force is toward the right and is decreasing in strength (magnitude).</p>
	<p>D. No applied force is needed</p>
	<p>E. The force is toward the left and is decreasing in strength (magnitude).</p> <p>F. The force is toward the left and is of constant strength (magnitude).</p> <p>G. The force is toward the left and is increasing in strength (magnitude).</p>

- _____ 1. Which force would keep the sled moving toward the right and speeding up at a steady rate (constant acceleration)?
- _____ 2. Which force would keep the sled moving toward the right at a steady (constant) velocity?
- _____ 3. The sled is moving toward the right. Which force would slow it down at a steady rate (constant acceleration)?
- _____ 4. Which force would keep the sled moving toward the left and speeding up at a steady rate (constant acceleration)?
- _____ 5. The sled was started from rest and pushed until it reached a steady (constant) velocity toward the right. Which force would keep the sled moving at this velocity?
- _____ 6. The sled is slowing down at a steady rate and has an acceleration to the right. Which force would account for this motion?
- _____ 7. The sled is moving toward the left. Which force would slow it down at a steady rate (constant acceleration)?

Questions 8-10 refer to a toy car which is given a quick push so that it rolls up an inclined ramp. After it is released, it rolls up, reaches its highest point and rolls back down again. *Friction is so small it can be ignored.*



Use one of the following choices (A through G) to indicate the **net force** acting on the car for each of the cases described below. Answer choice J if you think that none is correct.

- | | |
|--|--|
| (A) Net constant force down ramp | (E) Net constant force up ramp |
| (B) Net increasing force down ramp | (F) Net increasing force up ramp |
| (C) Net decreasing force down ramp | (G) Net decreasing force up ramp |
| (D) Net force zero | |

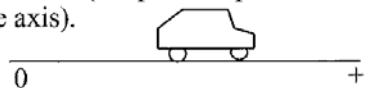
- _____ 8. The car is moving up the ramp after it is released.
 _____ 9. The car is at its highest point.
 _____ 10. The car is moving down the ramp.

Questions 11-13 refer to a coin which is tossed straight up into the air. After it is released it moves upward, reaches its highest point and falls back down again. Use one of the following choices (A through G) to indicate the force acting on the coin for each of the cases described below. Answer choice J if you think that none is correct. **Ignore any effects of air resistance.**

- A. The force is **down** and constant.
- B. The force is **down** and increasing
- C. The force is **down** and decreasing
- D. The force is zero.
- E. The force is **up** and constant.
- F. The force is **up** and increasing
- G. The force is **up** and decreasing

- _____ 11. The coin is moving upward after it is released.
 _____ 12. The coin is at its highest point.
 _____ 13. The coin is moving downward.

Questions 14-21 refer to a toy car which can move to the right or left along a horizontal line (the positive part of the distance axis).

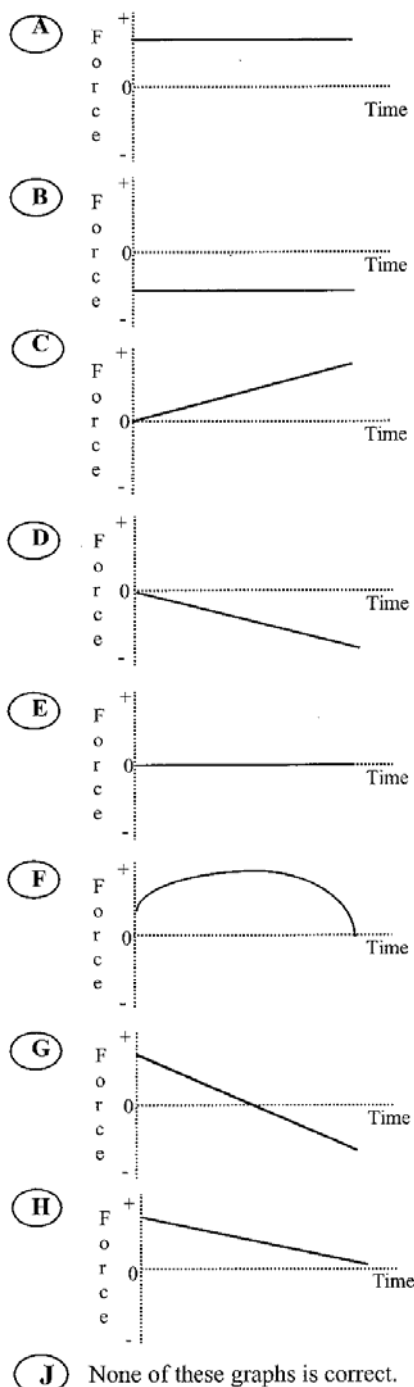


Assume that friction is so small that it can be ignored.

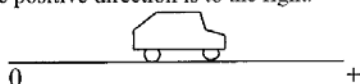
A force is applied to the car. Choose the one force graph (A through H) for each statement below which could allow the described motion of the car to continue.

You may use a choice more than once or not at all. If you think that none is correct, answer choice **J**

- ___14. The car moves toward the right (away from the origin) with a steady (constant) velocity.
- ___15. The car is at rest.
- ___16. The car moves toward the right and is speeding up at a steady rate (constant acceleration).
- ___17. The car moves toward the left (toward the origin) with a steady (constant) velocity.
- ___18. The car moves toward the right and is slowing down at a steady rate (constant acceleration).
- ___19. The car moves toward the left and is speeding up at a steady rate (constant acceleration).
- ___20. The car moves toward the right, speeds up and then slows down.
- ___21. The car was pushed toward the right and then released. Which graph describes the force after the car is released.

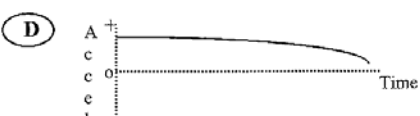
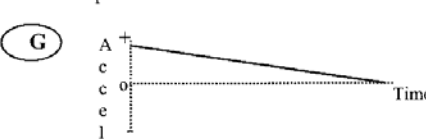
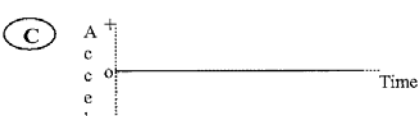
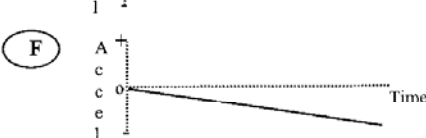
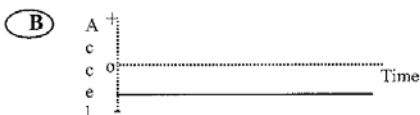
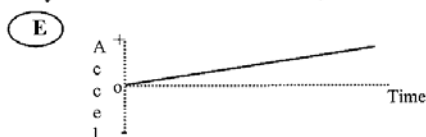
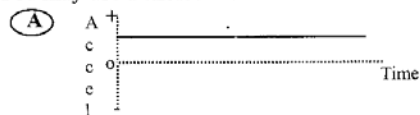


Questions 22-26 refer to a toy car which can move to the right or left on a horizontal surface along a straight line (the + distance axis). The positive direction is to the right.



Different motions of the car are described below. Choose the letter (A to G) of the **acceleration-time** graph which corresponds to the motion of the car described in each statement.

You may use a choice more than once or not at all. If you think that none is correct, answer choice J.



(J) None of these graphs is correct.

22. The car moves toward the right (away from the origin), speeding up at a steady rate.
 23. The car moves toward the right, slowing down at a steady rate.
 24. The car moves toward the left (toward the origin) at a constant velocity.
 25. The car moves toward the left, speeding up at a steady rate.
 26. The car moves toward the right at a constant velocity.

Questions 27-29 refer to a coin which is tossed straight up into the air. After it is released it moves upward, reaches its highest point and falls back down again. Use one of the following choices (A through G) to indicate the acceleration of the coin during each of the stages of the coin's motion described below. Take **up** to be the **positive** direction. Answer choice J if you think that none is correct.

- A. The acceleration is in the negative direction and constant.
 B. The acceleration is in the negative direction and increasing
 C. The acceleration is in the negative direction and decreasing
 D. The acceleration is zero.
 E. The acceleration is in the positive direction and constant.
 F. The acceleration is in the positive direction and increasing
 G. The acceleration is in the positive direction and decreasing

27. The coin is moving upward after it is released.
 28. The coin is at its highest point.
 29. The coin is moving downward.

Questions 30-34 refer to collisions between a car and trucks. For each description of a collision (30-34) below, choose the one answer from the possibilities A through J that best describes the forces between the car and the truck.

- A. The truck exerts a greater amount of force on the car than the car exerts on the truck.
- B. The car exerts a greater amount of force on the truck than the truck exerts on the car.
- C. Neither exerts a force on the other; the car gets smashed simply because it is in the way of the truck.
- D. The truck exerts a force on the car but the car doesn't exert a force on the truck.
- E. The truck exerts the same amount of force on the car as the car exerts on the truck.
- F. Not enough information is given to pick one of the answers above.
- J. None of the answers above describes the situation correctly.

In questions 30 through 32 the truck is **much heavier** than the car.



- ____ 30. They are both moving at the same speed when they collide. Which choice describes the forces?
- ____ 31. The car is moving much faster than the heavier truck when they collide. Which choice describes the forces?
- ____ 32. The heavier truck is standing still when the car hits it. Which choice describes the forces?

In questions 33 and 34 the truck is a **small pickup** and is the **same weight** as the car.



- ____ 33. Both the truck and the car are moving at the same speed when they collide. Which choice describes the forces?
- ____ 34. The truck is standing still when the car hits it. Which choice describes the forces?

Questions 35-38 refer to a large truck which breaks down out on the road and receives a push back to town by a small compact car.



Pick one of the choices A through J below which correctly describes the forces between the car and the truck for each of the descriptions (35-38).

- A. The force of the car pushing against the truck is equal to that of the truck pushing back against the car.
 - B. The force of the car pushing against the truck is less than that of the truck pushing back against the car.
 - C. The force of the car pushing against the truck is greater than that of the truck pushing back against the car.
 - D. The car's engine is running so it applies a force as it pushes against the truck, but the truck's engine isn't running so it can't push back with a force against the car.
 - E. Neither the car nor the truck exert any force on each other. The truck is pushed forward simply because it is in the way of the car.
 - J. None of these descriptions is correct.
- ____ 35. The car is pushing on the truck, but not hard enough to make the truck move.
 - ____ 36. The car, still pushing the truck, is **speeding up** to get to cruising speed.
 - ____ 37. The car, still pushing the truck, is at cruising speed and continues to travel at the **same speed**.
 - ____ 38. The car, still pushing the truck, is at cruising speed when the truck puts on its brakes and causes the car to **slow down**.

39. Two students sit in identical office chairs facing each other. Bob has a mass of 95 kg, while Jim has a mass of 77 kg. Bob places his bare feet on Jim's knees, as shown to the right. Bob then suddenly pushes outward with his feet, causing both chairs to move. In this situation, while Bob's feet are in contact with Jim's knees,

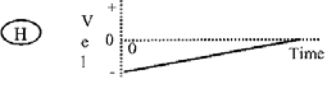
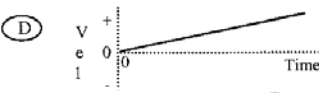
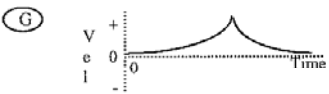
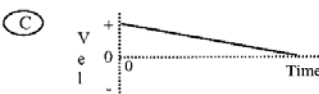
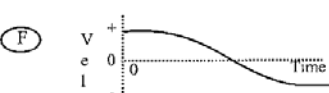
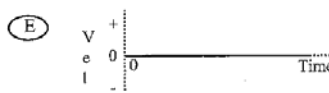
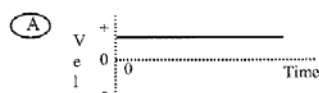


- A. Neither student exerts a force on the other.
 B. Bob exerts a force on Jim, but Jim doesn't exert any force on Bob.
 C. Each student exerts a force on the other, but Jim exerts the larger force.
 D. Each student exerts a force on the other, but Bob exerts the larger force.
 E. Each student exerts the same amount of force on the other.
 J. None of these answers is correct.

Questions 40-43 refer to a toy car which can move to the right or left along a horizontal line (the positive portion of the distance axis). The positive direction is to the right.



Choose the correct velocity-time graph (A - G) for each of the following questions. You may use a graph more than once or not at all. If you think that none is correct, answer choice J.



(J) None of these graphs is correct.

40. Which velocity graph shows the car moving toward the right (away from the origin) at a steady (constant) velocity?
 41. Which velocity graph shows the car reversing direction?
 42. Which velocity graph shows the car moving toward the left (toward the origin) at a steady (constant) velocity?
 43. Which velocity graph shows the car increasing its *speed* at a steady (constant) rate?

A sled is pulled up to the top of a hill. The sketch above indicates the shape of the hill. At the top of the hill the sled is released from rest and allowed to coast down the hill. At the bottom of the hill the sled has a speed v and a kinetic energy E (the energy due to the sled's motion). Answer the following questions. *In every case friction and air resistance are so small they can be ignored.*

44. The sled is pulled up a **steeper** hill of the **same** height as the hill described above. How will the velocity of the sled at the bottom of the hill (after it has slid down) compare to that of the sled at the bottom of the original hill? Choose the best answer below.
- A. The speed at the bottom is greater for the steeper hill.
 - B. The speed at the bottom is the same for both hills.
 - C. The speed at the bottom is greater for the original hill because the sled travels further.
 - D. There is not enough information given to say which speed at the bottom is faster.
 - J. None of these descriptions is correct.
45. Compare the kinetic energy (energy of motion) of the sled at the bottom for the original hill and the steeper hill in the previous problem. Choose the best answer below.
- A. The kinetic energy of the sled at the bottom is greater for the steeper hill.
 - B. The kinetic energy of the sled at the bottom is the same for both hills.
 - C. The kinetic energy at the bottom is greater for the original hill.
 - D. There is not enough information given to say which kinetic energy is greater.
 - J. None of these descriptions is correct.
46. The sled is pulled up a **higher** hill that is **less** steep than the original hill described before question 44. How does the speed of the sled at the bottom of the hill (after it has slid down) compare to that of the sled at the bottom of the original hill?
- A. The speed at the bottom is greater for the higher but less steep hill than for the original.
 - B. The speed at the bottom is the same for both hills.
 - C. The speed at the bottom is greater for the original hill.
 - D. There is not enough information given to say which speed at the bottom is faster.
 - J. None of these descriptions is correct.
- 46a. Describe in words your reasoning in reaching your answer to question 46. (**Answer on the answer sheet** and use as much space as you need)
47. For the higher hill that is less steep, how does the kinetic energy of the sled at the bottom of the hill after it has slid down compare to that of the original hill?
- A. The kinetic energy of the sled at the bottom is greater for the higher but less steep hill.
 - B. The kinetic energy of the sled at the bottom is the same for both hills.
 - C. The kinetic energy at the bottom is greater for the original hill.
 - D. There is not enough information given to say which kinetic energy is greater.
 - J. None of these descriptions is correct.

Appendix D: Students' Biographical Information

This test is for research purposes and it will be treated confidential.

1. BIOGRAPHICAL INFORMATION

Surname:_____

Name(s):_____

Name of Institution:_____

Male/Female:_____

Age:_____

School where Grade 12 was passed:_____

Year in which Grade 12 was passed:_____

Grade 12 Physical Science symbol or mark (HG/SG):_____

Did you do Bridging/Foundation? YES/NO:_____

(i) Bridging subjects

attended:_____

(ii) At which institution?:_____

2. FORCE AND MOTION CONCEPTUAL EVALUATION TEST

- | | | |
|---------|---------|---------|
| 1.____ | 21.____ | 40.____ |
| 2.____ | | 41.____ |
| 3.____ | 22.____ | 42.____ |
| 4.____ | 23.____ | 43.____ |
| 5.____ | 24.____ | |
| 6.____ | 25.____ | 44.____ |
| 7.____ | 26.____ | 45.____ |
| | | 46.____ |
| | 27.____ | 47.____ |
| 8.____ | 28.____ | |
| 9.____ | 29.____ | |
| 10.____ | | |
| | 30.____ | |
| 11.____ | 31.____ | |
| 12.____ | 32.____ | |
| 13.____ | 33.____ | |
| | 34.____ | |
| 14.____ | | |
| 15.____ | 35.____ | |
| 16.____ | 36.____ | |
| 17.____ | 37.____ | |
| 18.____ | 38.____ | |
| 19.____ | 39.____ | |
| 20.____ | | |

46 a. _____

Appendix E: Physics I Mechanics Examination Question Papers (2004)

Institution 2 Question Paper

PHY1521-JUN 2004

QUESTION 1

- 1.1 Derive the four kinematic equations of motion for a particle moving along the x axis with uniform acceleration. (10)
- 1.2 A train which normally runs at 40 m/s over a certain section of the journey is checked by signal to 10 m/s over 2 km of the section in which the railroad is under repair. The train covers 2 km while slackening speed for this purpose and 3 km while recovering its normal speed. Assuming the retardation and acceleration to be constant, find the time lost due to the check. (12)
- 1.3 A projectile is fired with an initial speed v_0 at an angle θ above the surface of an incline, which is in turn inclined at an angle ϕ above the horizontal. Show that the distance, measured along the incline, from the launch point to where the object strikes the incline is given by

$$R = \frac{2v_0^2 \cos(\theta + \phi)}{g \cos^2 \theta} \sin \phi \quad (12)$$

[34]

QUESTION 2

- 2.1 A stone attached to the end of a rope moves in a *vertical* circle solely under the influence of gravity and the tension in the rope. Find the tension in the rope at the following points: (a) when the rope is at angle θ to the vertical; (b) at the highest point; (c) at the lowest point. (8)
- 2.2 In Figure 2 the pulley is frictionless, and the coefficient of friction between the blocks and between the lower block and the horizontal surface is 0.6. A horizontal force $F = 90 \text{ N}$ is exerted on the upper block.

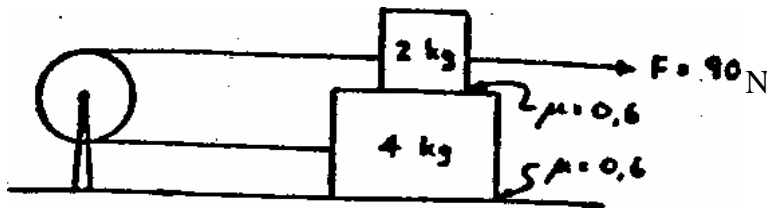


Figure 2

Calculate the acceleration of each block and the tension in the cord connecting the blocks. (16)

2.3 A body of mass m is projected vertically upward from the Earth's surface. Show that the *escape speed* is given by

$$v_{esc} = \sqrt{\frac{2GM_E}{R_E}} \quad (9)$$

[33]

QUESTION 3

3.1 Derive the work-energy theorem, $W = \Delta K$. (10)

3.2 A 2 kg block situated on a rough incline is connected to a spring of negligible mass having a spring constant of 100 N/m as in Figure 3. The block is released from rest when the spring is unstretched and the pulley is frictionless. The block moves 20.0 cm down the incline before coming to rest. Calculate the coefficient of kinetic friction between the block and the incline.

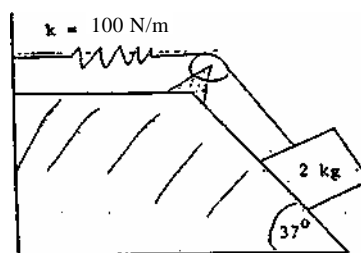


Figure 3

(12)

- 3.3 A ladder of length L and negligible mass rests against a frictionless wall at an angle θ to the horizontal. The coefficient of static friction is 0.5 at the floor. A person of mass M stands at a point $2L/3$ from the bottom. Calculate the minimum value of θ for the ladder to be in equilibrium

(11)

[33]

END OF PAPER

Institution 3 Question Paper

QUESTION 1

- i) What are derived physical quantities in mechanics? Give an example. (2)
- ii) The period T of a simple pendulum depends on its length l , acceleration due to gravity g and possibly the mass of the bob, m . use dimensional analysis to find the relationship. (4)
- iii) Einstein's theory of relativity shows that the energy E of a particle traveling at very high speed is given in terms of its rest mass m_0 , momentum p , and the speed of light in vacuum c , by an equation of the form

$$E^2 = p^a c^b + m^d c^e$$

Use dimensional arguments to find the values of a , b , d , and e .

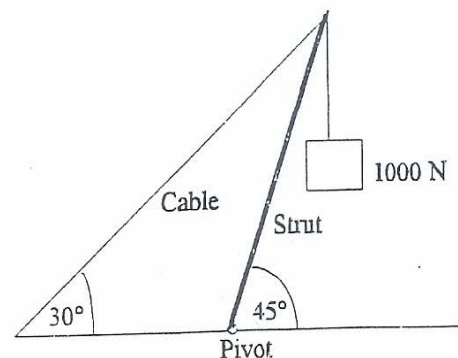
(4)
[10]

QUESTION 2

- i) If B is added to A , under what condition does the resultant $A + B$ have magnitude equal to $A + B$? Under what condition is the resultant vector equal to zero? (2)
- ii) A particle moving in the xy plane undergoes a displacement $s = (2.0\mathbf{i} + 3.0\mathbf{j})\text{m}$ while a constant force $F = (5.0\mathbf{i} + 2.0\mathbf{j})\text{N}$ acts on the particle.
 - a) Calculate the magnitude of the displacement and that of the force.
 - b) Calculate the work done by the force F .
 - c) Calculate the angle between F and s .
 - d) Calculate $s \times F$.
 - e) When is $s \times F = 0$, and $s \cdot F = 0$ (5)

iii)

Calculate the tension in the cable and the magnitude of the force exerted on the pivot by the strut in the diagram on the right. The weight of the strut can be ignored. (3)



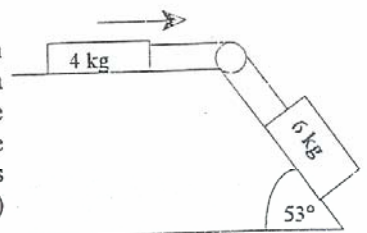
[10]

QUESTION 3

- i) Einstein was quoted as saying that if you could not explain a given concept to your grandmother, then you did not understand it. Write down the explanation of the following concepts that even Einstein's grandmother could understand:
- Displacement
 - Velocity
 - Acceleration
 - Center of gravity
 - Momentum
- (5)
- ii) A speed-trap consists of two cables 110 m apart. A motorist traveling at 90 km/h on a road where the speed limit is 60 km/h sees the speed-trap and slows down as she crosses the first cable. What must her deceleration be if her average speed over the 110 m is equal to the speed limit? How long will she take to slow down?
- (5)
- iii) Derive the formula for the horizontal range R , and the maximum height h , of a projectile motion in terms of v_0 , θ_0 and g .
- (5)
- iv) A stone is thrown with an initial velocity v_0 at 30° to the horizontal. When it hits the ground it is 100 m from its starting point. Calculate v_0 and the time of flight, t .
- (5)
- [20]

QUESTION 4

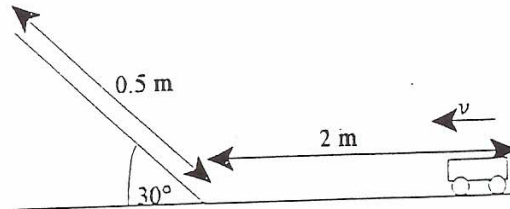
- i) Explain the following that even Newton's grandmother could understand them.
- Newton's first law
 - Newton's second law
 - Newton's third law
 - Newton's law of gravitation
 - The person sitting behind you in the bus is drinking an extremely hot black coffee. The driver of the bus tends to slam on the brakes quite suddenly and without warning. Should you be worried?
- (5)
- ii) The blocks, with masses 4 kg and 6 kg, are moving in the direction shown. The coefficient of friction between each block and the planes is 0.3. Calculate the acceleration of the blocks and the tension in the cord connecting them, assuming that the pulley is frictionless.
- (5)



[10]

QUESTION 5

- i) A toy car is propelled along a horizontal stretch of track with initial speed v , see the figure below. After traveling 2 m along the horizontal it climbs a sloping section making an angle of 30° with the horizontal. It comes to rest after traveling 0.5 m up the slope. Calculate the value of v if the coefficient of friction between the car and the surface is 0.2 throughout the journey. (7)



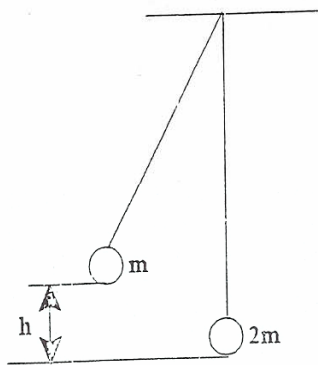
- ii) A man whose mass is 70 kg walks up to the third floor of the Q-block. This is a vertical height of 12 m above the ground floor.
- How much work has he done?
 - By how much has he increased his potential energy?
 - If he climbs the stairs in 20 s, what was his rate of working?

(3)

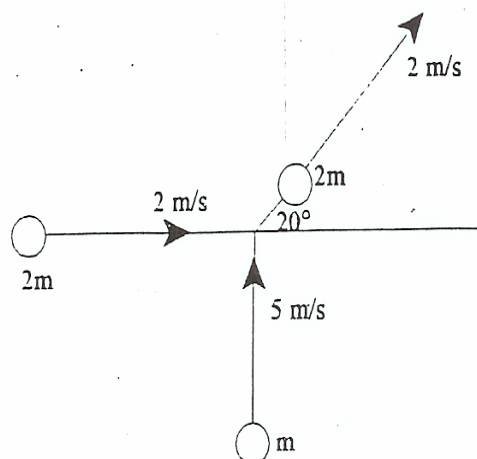
[10]

QUESTION 6

- i) What is an elastic collision? (1)
- ii) The pendulum ball of mass m shown below is pulled aside and released. It collides with another pendulum ball of mass $2m$ which is at rest. After collision the two balls stick together. How high in terms of h does the combination swing? (4)



iii)



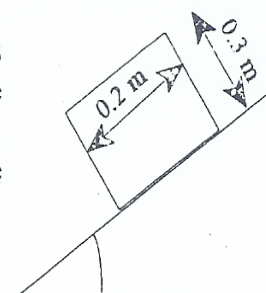
Two skaters, of mass $2m$ and m respectively, are initially moving at right angles to each other as shown in the diagram above. They collide, and the skater of mass $2m$ moves off with the same speed as before, but with his path deflected by 20° .

- Calculate the speed and direction of the lighter skater after the collision.
- Show, by means of a calculation, whether energy has been conserved in the collision.

(5)
[10]

QUESTION 7

- What is meant by equilibrium of an extended rigid body? (1)
- What is a couple? (1)
- A uniform ladder of length 10 m and mass 40 kg stands against a smooth vertical wall with its foot 6 m from the wall. The coefficient of friction between the foot of the ladder and the floor is 0.4. A man of mass 80 kg climbs up the ladder. Calculate:
 - the value of the frictional force F between the foot of the ladder and the floor when the man is half-way up the ladder,
 - the maximum value of F , when the ladder starts to slip,
 - how far up the ladder is he when this happens (when the ladder starts to slip)? (5)
- A uniform block is placed on a surface which can be tilted as shown. The coefficient of friction between the block and the surface is 0.7. As the surface is tilted from the horizontal, determine with the aid of a diagram and equations, whether the block will slide first or topple first. (3)



TOTAL = 80 marks

[10]

Institution 4 Question Paper

MODULE	PHYS 135 – MECHANICS
MARKS	64
INSTRUCTIONS	ANSWER ALL QUESTIONS

QUESTION 1

ANSWER ALL QUESTIONS BY WRITING DOWN **ONLY** THE NUMBER OF THE CORRECT ANSWER e.g., 1(a); 2(b) etc.

- (1) A ball is thrown upward by a baseball catcher. After it leaves his throwing hand, its acceleration:
- (a) is zero.
 - (b) is upward.
 - (c) decreases.
 - (d) is constant.
 - (e) increases.
- (2) Motion is accelerated **ONLY** if the
- (a) velocity changes at a constant rate.
 - (b) velocity changes in magnitude.
 - (c) velocity changes in direction.
 - (d) velocity changes in both direction and magnitude.
 - (e) velocity changes in either magnitude or direction.
- (3) An automobile is accelerated from rest with a constant acceleration of 1.2 m/s^2 . After the car has travelled a distance of 80 m, its speed is
- (a) 14 m/s
 - (b) 192 m/s
 - (c) 96 m/s
 - (d) 9.8 m/s
 - (e) 67 m/s
- (4) The torque about the base support of a diving board exerted by a 100-kg diver 3.0 m from the support is
- (a) 100 kg
 - (b) 980 N
 - (c) $2.9 \times 10^3 \text{ Nm}$
 - (d) 300 Nm
 - (e) none of the above
- (5) A bullet shot from a gun held in a horizontal position
- (a) strikes the ground much later than one dropped vertically from the same point at the same instant.
 - (b) is stopped by air resistance alone.
 - (c) strikes the ground at approximately the same time as one dropped vertically from the same point at the same instant.

- (d) travels in a straight path.
 - (e) strikes the ground much sooner than one dropped vertically from the same point at the same instant
- (6) Two forces of magnitude f_1 and f_2 , act at the same time on a mass m . The greatest acceleration which the mass can receive is
- (a) $m/(f_1 f_2)$
 - (b) $f_1 f_2 m$
 - (c) $(f_1 + f_2)/m$
 - (d) $(f_1 + f_2)m$
 - (e) $m/(f_1 + f_2)$
- (7) Which of these is a vector quantity?
- (a) uniform speed around a circle
 - (b) density
 - (c) speed
 - (d) mass
 - (e) volume
- (8) A vector quantity may be distinguished from a scalar because it has
- (a) constant properties
 - (b) direction
 - (c) magnitude
 - (d) force
 - (e) length
- (9) A rock of mass 60 kg is resting on a paved road. The force exerted on the rock by the road is:
- (a) 60 N
 - (b) 60 kg
 - (c) 588 kg
 - (d) zero
 - (e) 588 N
- (10) An object with initial velocity v would, in the absence of interaction with other objects,
- (a) eventually slow down and stop
 - (b) continue indefinitely with constant velocity
 - (c) continue indefinitely with constant acceleration
 - (d) eventually reach the speed of light
 - (e) pursue an unpredictable path since its acceleration is not constant.
- (11) The weight of a body is
- (a) simply another term for its mass
 - (b) a constant
 - (c) determined by means of a beam balance
 - (d) dependent on the locality in which it is determined
 - (e) always expressed in newtons.

[2x11=22]

QUESTION 2

- (a) Two crates, one with mass 4.00 kg and the other with mass 6.00 kg, sit on a frictionless surface of a frozen pond, connected by a light rope as in the Fig. 1. A woman wearing golf shoes (so that she can get traction on the ice) pulls horizontally on the 6.00-kg crate with a force \mathbf{F} that gives the crate an acceleration of 3.00 m/s^2 .

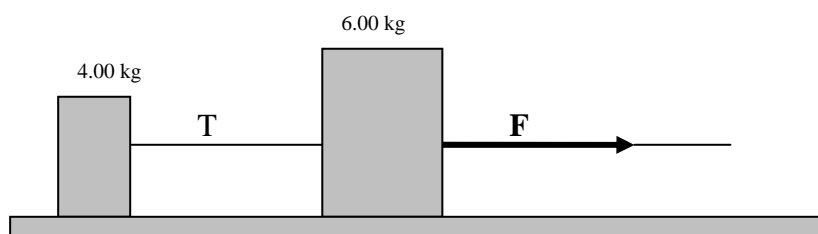


Figure 1.

Determine the

- (i) magnitude of the force \mathbf{F} ? (3)
(ii) tension T in the rope connecting the two crates? (3)
- (b) Two tugboats pull a disabled supertanker. Each tug exerts a constant force of $1.50 \times 10^6 \text{ N}$, one 16° north of west and the other 16° south of west, as they pull the tanker 650 m toward the west.
Determine the total work done on the supertanker? (6)
- (c) A moving electron has kinetic energy K_1 . After a net amount of work W has been done on it, the electron is moving one-fourth as fast in the opposite direction.
Determine W in terms of K_1 . (6)

[18]

QUESTION 3

- (a) A force of 800 N stretches a certain spring a distance of 0.10 m. Determine
(i) the potential energy of the spring when it is stretched 0.10 m (5)
(ii) its potential energy when it is compressed 0.050 m (2)
- (b) A small rock with a mass of 0.10 kg is released from rest at point A, which is at the top edge of a large hemispherical bowl with radius $R = 0.60 \text{ m}$ (Fig. 2). Assume that the size of the rock is small in comparison to the radius of the bowl, so the rock can be treated as a particle. The work done by friction on the rock when it moves from point A to point B at the bottom of the bowl is -0.22 J .
Determine the speed of the rock when it reaches point B? (6)

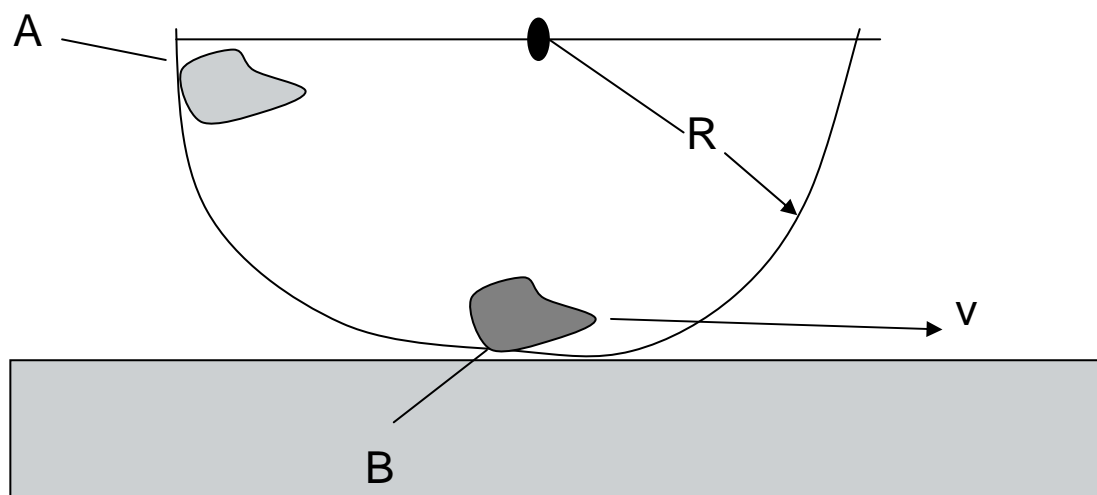


Figure 2.

- (c) A ball with radius $r_1 = 0.060$ m and mass 1.00 kg is attached by a light rod 0.400 m in length to a second ball with radius $r_2 = 0.080$ m and mass 3.00 kg as indicated in a Fig. 3. Determine the centre of gravity of this system.

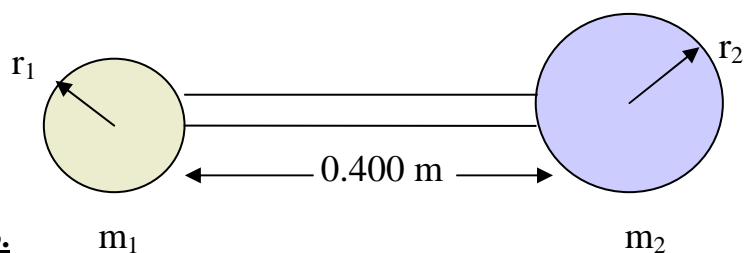


Figure 3.

- (d) State Newton's law of gravitation. (3)
- (e) Two uniform spheres, each of mass M and radius R , touch each other. Determine the magnitude of their gravitational force of attraction? (4)

[24]