The Alignment of the National Senior Certificate Examinations (November 2014 - March 2018) and the Curriculum and Assessment Policy Statement Grade 12 Physical Sciences: Physics (P1) in South Africa

by

Nishaal Bhaw

submitted in accordance with the requirements for

the degree of

MASTER OF SCIENCE IN MATHEMATICS, SCIENCE AND TECHNOLOGY EDUCATION

in the subject

PHYSICS EDUCATION

at the

UNIVERSITY OF SOUTH AFRICA

SUPERVISOR: PROF J. KRIEK

June 2018

DECLARATION

I declare that

THE ALIGNMENT OF THE NATIONAL SENIOR CERTIFICATE EXAMINATIONS (NOVEMBER 2014 - MARCH 2018) AND THE CURRICULUM AND ASSESSMENT POLICY STATEMENT FOR GRADE 12 PHYSICAL SCIENCES IN SOUTH AFRICA.

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

N BHAW

3 July 2018

DATE

ABSTRACT

The Department of Basic Education (DBE) has associated the poor pass rate in the National Senior Certificate (NSC) Grade 12 Physical Sciences examinations to the learners' lack of practical skills and the inability of learners to solve problems by integrating knowledge from the different topics in Physical Sciences. The CAPS (Curriculum and Assessment Policy Statement) is central to the planning, organising and teaching of Physical Sciences. Even though more than a third of the learners achieved below 30% in the NSC Grade 12 Physical Sciences: Physics (P1) November 2017 examination, there was a lack of references made to the CAPS, rationalising the poor performance. A disjointed alignment between the CAPS and the P1 is a possible cause for the poor performance. Since there have been no previous studies that investigated the alignment between the CAPS and the P1, this study aims to fill that gap. This study used a positivist research paradigm and a case study research strategy. A purposive sampling procedure selected the CAPS Grades 10 – 12 Physical Sciences document; the Physical Sciences Examination Guidelines Grade 12 documents and the final and supplementary P1 examinations in the period starting November 2014 to March 2018 as the documents for analysis. A summative content analysis research technique was conducted using the Surveys of Enacted Curriculum (SEC) research method. The SEC method employed the use of the four topics of Grade 12 Physics and the four non-hierarchical levels of cognitive demand as described in the modified version of Bloom's taxonomy. The physics topics included mechanics; waves, sound and light; electricity and magnetism; and optical phenomena. The cognitive demand levels included recall; comprehension; application and analysis; and synthesis and evaluation. This study found a 100 percent categorical coherence, a 67.3 percent balance of representation, a 79.4 percent cognitive complexity and an average Porter's alignment index of 0.77 between the CAPS and the P1. The overall Cohen's kappa for all the documents analysed was 0.88. The findings of this study indicate that the mechanics topic was under-emphasised whilst the application and analysis cognitive demand was over-emphasised in the P1. The CAPS and the P1 did not utilise the highest cognitive demand, synthesis and evaluation which may be interpreted as an environment that fosters lower order thinking. To change this environment of lower order thinking and simultaneously increase the alignment between the CAPS and the P1 this study recommends that firstly, the CAPS decreases the recall based content of the mechanics topic. Secondly, the CAPS and the P1 increase the synthesis and evaluation cognitive demand-based content at the expense of the recall cognitive demand-based content. Thirdly, the CAPS must include the content of the school-based physics practical assessments while decreasing the focus on physics definitions. The ultimate aim is an improvement in the pass rates of the NSC Grade 12 Physical Sciences examinations.

KEYWORDS

Department of Basic Education South Africa, Curriculum and Assessment Policy Statement, National Senior Certificate Physical Sciences: Physics (P1) examination, Surveys of Enacted Curriculum, Alignment index, Bloom's taxonomy, Bernstein's pedagogical device.

ACRONYMS, ABBREVIATIONS AND SYMBOLS

Ah	-	Amp hour (Unit of charge).
AI	-	Alignment index.
C2005	-	Curriculum 2005.
CAPS	-	Curriculum and Assessment Policy Statement.
CDL	-	Cognitive demand level.
CDL1	-	Cognitive demand level 1 – recall.
CDL2	-	Cognitive demand level 2 – comprehension.
CDL3	-	Cognitive demand level 3 – application and analysis.
CDL4	-	Cognitive demand level 4 – synthesis and evaluation.
DBE	-	Department of Basic Education.
DoE	-	Department of Education.
f	-	Frequency.
f_0	-	Threshold frequency.
FET	-	Further Education and Training.
GET	-	General Education and Training.
h	-	Planck's constant.
LSTM	-	Learner Support Teaching Material.
m	-	Mass.
MCQ	-	Multiple choice question.
NCS	-	National Curriculum Statements.
NSC	-	National Senior Certificate.
OBE	-	Outcomes Based Education.
Ω	-	Ohms (Unit of resistance).
P1	-	NSC Grade 12 Physical Sciences – Physics Paper 1.
P2	-	NSC Grade 12 Physical Sciences – Chemistry Paper 2.
PST	-	Physics topic.
PST1	-	Grade 12 Physical Sciences topic 1 – mechanics.
PST2	-	Grade12 Physical Sciences topic 2 – waves, sound and light.
PST3	-	Grade12 Physical Sciences topic 3 – electricity and magnetism.

PST4	-	Grade12 Physical Sciences topic 4 – optical phenomena.
RNCS	-	Revised National Curriculum Standards.
SA	-	South Africa.
SAQA	-	South African Qualifications Authority.
SBA	-	School Based Assessment.
SEC	-	Survey of Enacted Curriculum.
V	-	Volts (Unit of Potential Difference).
v	-	Velocity.

DEFINITION OF TERMINOLOGY

This study uses the followng terminology:

Absolute differences matrix	:	A two-dimensional table obtained by the absolute difference of the examination ratio matrix from the corresponding cells of the curriculum ratio matrix.
Alignment	:	The alignment between educational components refers to the degree of agreement between them..
Bloom's taxonomy	:	A hierarchical classification system that defined and distinguished different levels of learner cognition. The taxonomy has six levels of cognitive demand: knowledge, comprehension, application, analysis, synthesis and evaluation.
CAPS	:	The use of CAPS in this study refers to the combined Grade 12 Physics content of the CAPS Grades 10 – 12 Physical Sciences and the Grade 12 Examination Guidelines Physical Sciences.
Cognitive demand level	:	The level of memory and attentional resources required to accomplish a task successfully.
Educational components	:	Educational components refers to the assessment (examinations), the instruction (teaching) and the standards (curriculum) of an education system.
Elective subject	:	A list of approved subjects by the Department of Basic Education. The minimum number of elective subjects for the National Senior Certificate qualification is three.
Frequency matrix	:	A two-dimensional table consisting of physics topics and cognitive demand levels. The data is obtained from a tally of the cognitive demand levels within each physics topic.

Frequency matrix total	:	The sum total of all the cell values of the frequency matrix.
Fundamental subject	:	Fundamental subjects consist of two languages, a first language and a first additional language, life orientation as well as mathematics or mathematics literacy.
Guidelines	:	The National Senior Certificate Examination Guidelines Physical Sciences Grade 12.
Modified cognitive taxonomy	:	The modified cognitive taxonomy has four non-hierarchical levels of leaner cognition: recall, comprehension, application and analysis, and synthesis and evaluation.
Matrix	:	A two-dimensional table of data having physics topics along the rows and cognitive demand levels along the columns.
National Curriculum Statement Grades R – 12	:	A Department of Education curriculum that offered articulation to the information, aptitudes, and qualities learned in Grade R to Grade 12.
P1	:	National Senior Certificate Physical Sciences: Physics (P1) examination.
P2	:	National Senior Certificate Physical Sciences: Chemistry (P2) examination.
Physics	:	Refers to the physics discipline of the National Senior Certificate Physical Sciences subject.
Physics topics	:	There are four central topics in Grade 12 Physics: mechanics; waves, sound and light; electricity and magnetism; and optical phenomena.

Porter’s alignment method	:	A quantitative method that used two dimensionally equally ratio matrices to determine the alignment between the curriculum and the examination. The method produces an alignment index (AI) that ranges between zero and one. An AI of zero indicates no alignment and an AI of one indicates complete alignment.
Ratio matrix	:	A two-dimensional table consisting of physics topics and cognitive demand levels obtained by dividing each cell value of the frequency matrix by the frequency matrix total.
Surveys of Enacted Curriculum	:	The Survey of Enacted Curriculum is a tool used for the content classification of educational components. The tool evaluated subject content based on cognitive demand levels and produced an alignment index.
Taxonomy	:	Taxonomy is a branch of science that deals with classification.

LIST OF TABLES

Table 1 *Physical Sciences Learner Performance* ... 5

Table 3 *Teaching Time for Physics* ... 19

Table 4 *Assessment Components of Physical Sciences* ... 20

Table 5 *Practical Experiments for Physical Sciences* ... 21

Table 6 *Physical Sciences Pass Rates* ... 22

Table 7 *Physical Sciences Examination Diagnostic Feedback Summary* ... 23

Table 8 *Curriculum and Assessment Alignment Global Studies* ... 25

Table 9 *Spiral Design of the CAPS Grade 10 – 12 Physical Sciences* ... 27

Table 10 *Cognitive Demand Level Skills* ... 30

Table 11 *Cognitive Demand Level Verbs* ... 31

Table 12 *NSC Physics Examination Topic Weighting* ... 34

Table 15 *CAPS Grade 12 Physics and Guidelines Classification Rubric* ... 49

Table 16 *P1 Classification Rubric* ... 49

Table 17 *Cohen's Kappa Interrater Reliability Coefficient* ... 51

Table 18 *Summary of Research Design and Methodology* ... 58

Table 19 *Cognitive Demand Level of the CAPS Grade 12 Physics* ... 61

Table 20 *Time Allocation and Subtopics in the CAPS Grade 12 Physics* ... 62

Table 21 *CAPS Grade 12 Physics Topic Weighting* ... 62

Table 22 *CAPS Grade 12 Physics Cognitive Demand Level Weighting* ... 63

Table 23 *CAPS Grade 12 Physics Frequency Matrix* 64

Table 25 *Guidelines 2014 Physics Topic Weighting* 68

Table 26 *Guidelines 2014 Cognitive Demand Level Weighting* 69

Table 27 *Guidelines 2014 Frequency Matrix* 70

Table 28 *CAPS 2014 Frequency Matrix* 70

Table 29 *CAPS 2014 Ratio Matrix* 71

Table 30 *P1 November 2014 Question One Coding Classification* 72

Table 31 *P1 November 2014 Question Two Coding Classification* 73

Table 32 *P1 November 2014 Question Three Coding Classification* 73

Table 35 *P1 November 2014 Question Six Coding Classification* 75

Table 36 *P1 November 2014 Question Seven Coding Classification* 75

Table 37 *P1 November 2014 Question Eight Coding Classification* 76

Table 38 *P1 November 2014 Question Nine Coding Classification* 77

Table 39 *P1 November 2014 Question Ten Coding Classification* 77

Table 40 *P1 November 2014 Physics Topic Weighting* 78

Table 41 *P1 November 2014 Cognitive Demand Weighting* 79

Table 42 *P1 November 2014 Frequency Matrix* 80

Table 43 *P1 November 2014 Ratio Matrix* 80

Table 44 *CAPS 2014 – P1 November 2014 Absolute Differences Matrix* 81

Table 45 *Alignment Index for the CAPS and the P1* 82

Table 46 *CAPS (2014 – 2017) Frequency Matrix Data* 83

Table 47 *P1 (November 2014 – March 2018) Frequency Matrix* 84

Table 48 *CAPS – P1 Physics Topic Classification* 84

Table 49 *CAPS – P1 Cognitive Demand Level Distribution* 86

Table 50 *Summary of the Alignment Criteria.* 88

LIST OF FIGURES

Figure 1. Feedback Mechanism of Assessment. 10

Figure 2. Levels of Cognitive Demand in Bloom's Taxonomy. 11

Figure 3. Revised Bloom's Taxonomy. 12

Figure 4. Cognitive Demand Levels in the Modified Bloom's Taxonomy. 13

Figure 5. Theoretical Framework. 14

Figure 7. P1 November 2014, Question 1.2. 45

Figure 8. P1 November 2014, Question 2. 46

Figure 9. Curriculum, Guidelines, and Examination Classification 54

Figure 10. Curriculum, Guidelines, and Examination Frequency Matrices 54

Figure 11. Curriculum and Guidelines Frequency Matrix 55

Figure 12. Curriculum, Guidelines, and Examination Ratio Matrix 55

Figure 13. Absolute Differences Matrix. 55

Figure 14. The Methodology. 57

Figure 15. Extract of the CAPS Grade 12 Physics. ... 60

Figure 16. CAPS Grade 12 Physics Cognitive Demand Distribution. ... 65

Figure 17. Extract of the Guidelines 2014 Optical Phenomena Topic. ... 66

Figure 18. Guidelines 2014 Cognitive Demand Distribution. ... 70

Figure 20. CAPS – P1 Physics Topic Distribution. ... 85

Figure 21. CAPS – P1 Cognitive Demand Distribution. ... 86

LIST OF EQUATIONS

Equation 1 *Alignment Index Calculation Tool* ... 49

Equation 2 *Porter's Alignment Equation* ... 53

TABLE OF CONTENTS

DECLARATION ... i

ABSTRACT ... ii

KEYWORDS ... iii

ACRONYMS, ABBREVIATIONS AND SYMBOLS ... iv

DEFINITION OF TERMINOLOGY ... vi

LIST OF TABLES ... ix

LIST OF FIGURES ... xi

LIST OF EQUATIONS ... xii

TABLE OF CONTENTS ... xiii

CHAPTER 1
INTRODUCTION

1.1 Background to the study. ... 1

1.2 Problem of the Study. ... 3

1.3 Rationale for the Study. ... 3

1.4 Research Objectives and Research Questions. ... 3

1.5 Significance of the Study. ... 4

1.6 Limitations of the Study. ... 6

1.7 Organisation of the Study. ... 6

1.8 Summary of Chapter One. ... 7

CHAPTER 2
LITERATURE SURVEY

2.1 Introduction. 8

2.2 The Theoretical Framework. 8

2.3 Context of the South African Education System...15

2.3.1 Department of Basic Education Grade Structure...15

2.3.2 The National Senior Certificate Qualification. 16

2.3.3 The Curriculum Changes in South Africa. 16

2.3.4 The Documentation of the CAPS based Physical Sciences...............................18

2.3.5 Physics Topics and Teaching...18

2.3.6 The Assessment Components in Physical Sciences...19

2.3.7 The Grade 12 Physical Sciences Learner Performance. 21

2.3.8 The NSC Examination Diagnostic Report Physical Sciences. 22

2.3.9 Alignment in Education. 23

2.3.10 Alignment Studies..24

2.4 The Curriculum and Assessment Policy Statement. 26

2.5 The Design of the CAPS FET Grade 10 – 12 Physical Sciences...............................26

2.6 Depth of Topics in the CAPS. 27

2.6.1 Cognitive Demand Level 1 (CDL1) – Recall. 28

2.6.2 Cognitive Demand Level 2 (CDL2) – Comprehension. 28

2.6.3 Cognitive Demand Level 3 (CDL3) – Application and Analysis......................28

2.6.4 Cognitive Demand Level 4 (CDL4) – Synthesis and Evaluation. 29

2.7 Breadth of the CAPS. 32

2.7.1 Physics Topic 1 (PST1) – Mechanics. 32

2.7.2 Physics Topic 2 (PST2) –Waves, sound and light. 32

2.7.3 Physics Topic 3 (PST3) – Electricity and magnetism. 32

2.7.4 Physics Topic 4 (PST4) – Optical Phenomena. 33

2.8 The Physical Sciences Examination Guidelines GRADE 12. 33

2.8.1 Physics Topic and Cognitive Demand Weighting in the Guidelines. 33

2.9 Alignment of the CAPS and P1 34

2.10 Traditional Methodologies of Alignment. 35

2.10.1 Sequential Development. 35

2.10.2 Expert Review. 35

2.10.3 Content Analysis. 35

2.11 Research Methods in Alignment Studies. 35

2.11.1 The Webb Method. 36

2.11.2 Achieve Method. 36

2.11.3 Surveys of Enacted Curriculum Alignment (SEC) Method. 37

2.12 Summary of Chapter Two. 37

CHAPTER 3
RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction. 38

3.2 Research Philosophy. 38

3.3 Research Strategy. 39

3.4 Research Approach...40

3.5 Sample Selection. 41

3.6 Research Process. 41

3.6.1 Preparing of the Data. 42

3.6.2 Defining the Coding Unit...42

3.6.3 Developing a Coding Scheme..42

3.6.4 Updating the Coding Scheme. 42

3.6.5 Coding the Documents..45

3.6.6 Assessing the Coding Consistency. 47

3.6.7 Using the Coded Data. 48

3.6.8 Reporting the Findings..48

3.7 Data Collection Instruments and Tools. 48

3.7.1 CAPS Grade 12 Physics and the Guidelines Classification Instrument. 48

3.7.2 P1 Classification Instrument. 49

3.7.3 Tool to Determine the Alignment between the CAPS and P1. 49

3.7.4 Validity and Reliability..50

3.8 Methodology. 52

3.8.1 Porter’s Alignment Equation. 52

3.8.2 Surveys of the Enacted Curriculum Method. 54

3.9 Summary of Chapter Three. 58

CHAPTER 4
DATA ANALYSIS AND FINDINGS

4.1 Introduction. 59

4.2 Analysis of the CAPS Grade 12 Physics. 59

4.3 Findings of the CAPS Grade 12 Physics Analysis. 62

4.4 Analysis of the Guidelines 2014. 65

4.5 Findings of the Guidelines 2014 Analysis. 68

4.6 Analysis of P1 November 2014 72

4.6.1 Question One Coding Classification. 72

4.6.2 Question Two Coding Classification. 73

4.6.3 Question Three Coding Classification. 73

4.6.4 Question Four Coding Classification. 74

4.6.5 Question Five Coding Classification. 74

4.6.6 Question Six Coding Classification. 75

4.6.7 Question Seven Coding Classification 75

4.6.8 Question Eight Coding Classification. 76

4.6.9 Question Nine Coding Classification 77

4.6.10 Question Ten Coding Classification. 77

4.7 Findings of the P1 November 2014 analysis. 78

4.8 Calculation of Porter's Alignment Index (AI). 81

4.9 Research Questions. 82

4.9.1 Research Question One. 82

4.9.2 Research Question Two. 83

4.9.3 Research Question Three. 85

4.9.4 Research Question Four. 87

4.10 Summary of Chapter Four. 87

CHAPTER 5
CONCLUSION

5.1 Overview. 89

5.2 Summary of Findings. 90

5.3 Discussion of the Findings. 91

5.4 Implications and Recommendations. 94

REFERENCES 96

APPENDIX

Appendix A. Classification Instrument for P1. 111

Appendix B. Classification Instrument for the CAPS. 112

Appendix C. Coding of the CAPS Grade 12 Physics. 113

Appendix D. Coding of the Guidelines 2014. 122

Appendix E. Coding of the Guidelines 2015. 131

Appendix F. Coding of the Guidelines 2016. 139

Appendix G. Coding of the Guidelines 2017. 147

Appendix H. Coding of P1 November 2014. 155

Appendix I. Coding of P1 March 2015...156

Appendix J. Coding of P1 November 2015. 157

Appendix K. Coding of P1 March 2016...158

Appendix L. Coding of P1 November 2016. 159

Appendix M. Coding of P1 March 2017...160

Appendix N. Coding of P1 November 2017. 161

Appendix O. Coding of P1 March 2018...162

Appendix P. Findings of the Guidelines 2015 Analysis..163

Appendix Q. Findings of the Guidelines 2016 Analysis..167

Appendix R. Findings of the Guidelines 2017 Analysis..171

Appendix S. Findings of the P1 March 2015 Analysis...177

Appendix T. Findings of the P1 November 2015 Analysis. 181

Appendix U. Findings of the P1 March 2016 Analysis...185

Appendix V. Findings of the P1 November 2016 Analysis. 189

Appendix W. Findings of the P1 March 2017 Analysis...193

Appendix X. Findings of the P1 November 2017 Analysis. 197

Appendix Y. Findings of the P1 March 2018 Analysis..201

Appendix Z. AI Calculation CAPS – P1 November 2014..205

Appendix AA. AI Calculation CAPS – P1 March 2015..206

Appendix BB. AI Calculation CAPS – P1 November 2015. 207

Appendix CC. AI Calculation CAPS – P1 March 2016..208

Appendix DD. AI Calculation CAPS – P1 November 2016. 209

Appendix EE. AI Calculation CAPS – P1 March 2017..210

Appendix FF. AI Calculation CAPS – P1 November 2017. 211

Appendix GG. AI Calculation CAPS – P1 March 2018..212

Appendix HH. Kappa Calculations. 213

Appendix II. Physics Topic Weighting in the Guidelines and the P1.................................215

ATTACHMENTS 217

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND TO THE STUDY.

For the South African education system to compete globally, the best practices of the top education systems in the world, such as those in Finland and Singapore, must be leveraged (Schleicher, 2012, p. 81). In Singapore there was an awareness that learning did not necessarily mean the mastery of subject content. For learners to become future leaders in the economy, they need to become critical thinkers and complex problem solvers; these were the type of thinkers that would be the highest in demand in the future economy (Yahya, 2017). The learners' ability to critically understand information and the ability to generate ideas from their understanding were essential to their futures. Changes in the Singaporean curricular policies and initiatives enabled a shift in focus from the knowledge of content to the development of learners as critical thinkers. The way forward in Singapore was to embark on school-based curriculum innovation that emphasised critical thinking across subject content at the national level (Koh, Lee, Ponnusamy, K. Tan, & L. Tan, 2017, p. 518). Finland is another example where curriculum changes similar to those applied in Singapore foster critical thinking in educators and learners. The aim of the Finnish education system was to create new models for school and teacher development – to ensure an increased alignment between the curricula and educational assessment (Schleicher, 2012, p. 83). Some of the outcomes of the policy changes included shorter school days, minimal homework, focus on play, free time and outdoor learning (Jackson, 2016). South Africa must adopt the best practices of global education leaders to achieve success in STEM (Science, Technology, Engineering and Mathematics) education. Not only must there be changes in the current education system but the South African government must support investment in STEM education, which includes an investment in STEM educators (Kennedy & Odell, 2014, p. 249). The number of tertiary level graduates becomes an essential measure of the success of Government investments towards STEM education.

The minimum admission requirement for entry into an undergraduate degree in the Sciences in South Africa is 50 percent in the Grade 12 Physical Sciences examination. The minimum entry for an undergraduate degree in Engineering is 60 percent in the Grade 12 Physical Sciences examination (Stellenbosch University, 2017; University of Cape Town, 2017; University of Johannesburg, 2018; University of Kwa-Zulu Natal, 2016; University of Potchefstroom, 2017a, 2017b; University of Witwatersrand, 2018). On average, only 24 percent of the learners who wrote the Grade 12 Physical Sciences examination will meet the minimum entry requirement to study towards an undergraduate degree in the Sciences (Department of Basic Education (DBE), 2018a, p. 176). Furthermore, an average of only 14.3 percent of the learners will meet the minimum entry requirement to study towards an undergraduate degree in Engineering (DBE, 2018a, p. 176). The low percentage of learners studying Grade 12 Physical Sciences who qualify to study Engineering and the Sciences at the tertiary level is a concern.

A possible reason for the poor learner performance in Physical Sciences could be the non-alignment between the assessment and the curriculum (Squires, 2012, p. 129). Alignment studies allow for the analytical research of the various components of an educational system to compare their content and make decisions about how well they agree with each other (Martone & Sireci, 2009, p. 1337). Horizontal coherence is the alignment between the curriculum content and instructional activities with the assessment (Mhlolo & Venkat, 2009, p. 35). Traditional methodologies for determining the alignment between the assessment and the curriculum included sequential development, expert review and document analysis. This study used the Surveys of Enacted Curriculum (SEC) research method that includes four measures of alignment (Elliott, Kurz, Smithson, & Wehby, 2010, p. 132) which formed the basis of the research questions of this study.

The subject-specific documents of the Grade 12 Physical Sciences curriculum included the Curriculum and Assessment Policy Statement Further Education and Training Phase Grades 10–12 Physical Sciences document (DBE, 2011b) and the Examination Guidelines Physical Sciences Grade 12 documents (DBE, 2014b; DBE, 2015c; DBE, 2017c; South African Comprehensive Assessment Institute, 2016). These documents were jointly referred to as the CAPS. The assessment considered in this study are the final and supplementary Grade 12 Physical Sciences: Physics examinations (P1) from November 2014 to March 2018.

1.2 PROBLEM OF THE STUDY.

There is a problem of low learner achievement in Physical Sciences education (Kriek & Grayson, 2009, p. 185). The poor performance in physics causes learners to dislike the subject due to fear (Kriek, Ayene, & Damtie, 2010, p. 12) and this, in turn, compounds the problem of poor performance. The DBE acknowledged this problem and included the aim of increasing the number of learners that pass the Physical Sciences examinations in its action plan (DBE, 2018b, p. 1). However, the aim of increasing the number of learners that pass the Physical Sciences examinations was not achieved (DBE, 2018b, p. 61).

The CAPS is central to the organisation, planning, and teaching of physical sciences at school (DBE, 2011b, p. 5) hence, it is expected that the central document is the first point of reference for the problem of low learner achievement. However, the low rate of referral of the EDR to the CAPS (Table 7) is of concern. This study aims to determine the alignment between the CAPS and the P1 and assess the significance of this concern.

1.3 RATIONALE FOR THE STUDY.

The non-alignment between the curriculum and the examinations could be a possible reason for the poor learner performance in Physical Sciences (Squires, 2012, p. 129) The purpose of this study is to determine the alignment between the CAPS and the P1 using the SEC method. The P1s analysed in this study are the final (November) and supplementary (March) CAPS based examinations that were written in the period starting November 2014 to March 2018. The most recent study that investigated the alignment between the curriculum and examinations for Physical Sciences in South Africa was Edwards (2010), which study included three NSC based examinations. Since changing to the CAPS based Physical Sciences examinations in November 2014, there have been no further studies that examined the alignment between the CAPS and the P1. This study included the eight P1s (November 2014 – March 2018) based on the CAPS.

1.4 RESEARCH OBJECTIVES AND RESEARCH QUESTIONS.

The primary research objective of this study was to assess the alignment between the CAPS and the P1 for the period November 2014 to March 2018. The use of the SEC method provided four content focus criteria of alignment (Webb, 1997, p. 4) which assisted in developing the secondary research objectives of this study. The first research objective of this study is to determine the categorical concurrence between the CAPS and the P1 for the period November 2014 to March 2018. The second research objective is to determine the balance of representation between the CAPS and the P1 for the period November 2014 to March 2018. The third research objective is to determine the cognitive complexity between the CAPS and the P1 for the period November 2014 to March 2018. The fourth research objective is to determine Porter's alignment index between the CAPS and the P1 for the period November 2014 to March 2018.

Following from the research objectives of this study, the main research question of this study is to determine the alignment of the alignment of the P1 (November 2014 - March 2018) and the CAPS. This research question has four quantitative measures of alignment which includes matching Physics topics, relative emphasis of Physics topic coverage, relative emphasis of cognitive demand coverage and the alignment index. Each of the four measures of alignment formed the research sub-questions of this study. The first research sub-question: What is the measure of matching physics topics between the CAPS and the P1 for the period November 2014 to March 2018? The second research sub-question is: What is the measure of the relative emphasis of physics topics coverage between the CAPS and the P1 for the period November 2014 to March 2018? The third research sub-question is: What is the measure of the relative emphasis of the cognitive demand level coverage between the CAPS and the P1 for the period November 2014 to March 2018? The fourth research sub-question is: What is Porter's alignment index between the CAPS and the P1 for the period November 2014 to March 2018?

1.5 SIGNIFICANCE OF THE STUDY.

Collier (2017) affirmed that one of the eligibility criteria for an undergraduate degree in Engineering is a minimum of 60 percent in Grade 12 Physical Sciences. The eligibility for an undergraduate degree in the Sciences is a minimum of 50 percent in Grade 12 Physical Sciences (Stellenbosch University, 2017; University of Cape Town, 2017; University of Johannesburg, 2018; University of Kwa-Zulu Natal, 2016; University of Potchefstroom, 2017a, 2017b; University of Witwatersrand, 2018).

Table 1 shows that only an average of 24 percent of the learners that wrote the Grade 12 Physical Sciences examination will meet the minimum entry requirement to study an undergraduate degree in the Sciences. Furthermore, only an average of 14.3 percent of the learners will meet the minimum entry requirement for study an undergraduate degree in Engineering (DBE, 2018a, p. 176).

Table 1

Physical Sciences Learner Performance

Examination	% of learners obtained >50%	% learners obtained >60%
November 2014	22.4	13.1
November 2015	22.0	12.8
November 2016	24.8	14.9
November 2017	26.8	16.2
Average	24.0	14.3

Note. From "National Senior Certificate Examination 2017 Diagnostic Report Part 1" (DBE, 2018a, p. 176) In the public domain.

A student who wishes to pursue a degree in Engineering or the Sciences needs to choose Physical Sciences in the Grade 10 of the FET phase.

Table 1 shows that more than 75 percent of learners writing the Grade 12 Physical Sciences examinations will not gain access to undergraduate studies in the Sciences and more than 85 percent of learners writing the Grade 12 Physical Sciences examinations will not gain access to undergraduate studies in Engineering.

Squires (2012, p. 133) identified a connection between learner performance and the alignment between the curriculum and the examination: the more significant the alignment between the examinations and the curriculum, the higher the performance of learners. Schneider, Körkel, and Weinert (1989, p. 306) described low aptitude learners as learners that did not have a natural ability to learn and understand. Squires (2012, p. 133) further stated that the alignment between the curriculum and the examination is more important for low–aptitude learners than high–

aptitude learners, which may be due to the examination often including a higher cognitive demand than the curriculum. An assessment of the alignment between the CAPS and the P1 could provide a perspective on the cause of poor learner achievement in Grade 12 Physical Sciences. Any changes made to the design of the P1 and the CAPS to improve their alignment will be of benefit to both the learner and the educator. The ultimate aim is an improvement of the pass rates in Grade 12 Physical Sciences.

1.6 LIMITATIONS OF THE STUDY.

The classification of the documents in this study are based on a list of verbs (Table 11). A limitation of this study is that the classifications considered did not all contain explict verbs. In such instances the classification required substantive coding. Substantive coding has an element of rater effects and this may be a limitation of this study. The rater effects was quantified by the use of an interrater Kappa coefficient (Section 3.7.4.).

This study did not include an analysis of the components of the SBA such as class control tests, mid-year examinations, trial examinations and practical assessments. Although the SBA accounts for a quarter of the final Grade 12 Physical Sciences mark, this study does not focus on learner performance data, and its omission does not affect the findings of this study. This study only included the final and supplementary English medium P1 and omitted the Learning and Teachers Support Materials (LTSM) which includes workbooks and study guides.

1.7 ORGANISATION OF THE STUDY.

Chapter One presented the background, context, rationale, aim, problem statement and research questions of the study. This chapter included a discussion on the significance and the limitations of this study. In Chapter Two, the theoretical framework guiding this study as well as the literature reviewed, is presented. Chapter Three details the research methodology used in this study. The research design and a discussion of the instruments for data collection, was also presented in Chapter 3. Chapter Four presented the results and findings from the data analysis. The findings are used to answer the four research questions that guide this study. Chapter Five summarised and presented the findings, limitations, recommendations, and implications of the study.

1.8 SUMMARY OF CHAPTER ONE.

This chapter presented the background to the study, the problem of the study, the rationale for the study, research problems and research questions, the significance of the study, the limitations of the study and the organisation of the study. The next chapter presented a review of the literature.

CHAPTER 2

LITERATURE SURVEY

2.1 INTRODUCTION.

A survey of the literature on the alignment of the curriculum and the examination included a review of the literature on the education environment in South Africa, curriculum development and design, Grade 12 Physical Sciences examinations and alignment studies. The primary research period for journal articles was the period 2013 to 2018. The UNISA Library E-Journal Finder, EBSCOhost, and Google Scholar assisted in sourcing journal articles. The following keywords were used to search for journal articles: Department of Basic Education South Africa, Curriculum and Assessment Policy Statement, National Senior Certificate Physical Sciences: Physics examination, Surveys of Enacted Curriculum, Alignment index, Bloom's taxonomy and Bernstein's Pedagogical device.

2.2 THE THEORETICAL FRAMEWORK.

Bernstein's cognitive device and Bloom's taxonomy of the cognitive domain guides this study. Bernstein (1977) presented a structuralist view of education using three pillars: curriculum; pedagogy; and evaluation. Each pillar of education in Bernstein's cognitive device is a message system that delivers formal educational knowledge (Bertram, 2012, p. 5). Bertram (2012) further described the three pillars of education as a conceptualisation of Bernstein's pedagogical device which provides a mechanism for describing the concept of converting knowledge into pedagogic communication. This study used the curriculum and assessment pillars of education, leaving out the pedagogy pillar of education which was beyond the scope of this study.

The conversion of knowledge into pedagogic communication occurs via three interrelated hierarchical rules: distributive rules, re-contextualising rules and evaluative rules (Singh, 2002, p. 573). Distributive rules regulate the influence between social groups by ensuring the distribution of knowledge in various forms (Singh, 2002, p. 573). The re-contextualising rules regulate the formation of educational knowledge by moving institutional knowledge from its original state of production to another altered state of context (Bernstein, 1990, p. 184). The evaluative rules are concerned with the re-organising institutional knowledge into functional instruction texts such as a curriculum (Singh, 2002, p. 573).

The mechanisms of knowledge communication of Bernstein's pedagogical device follow a set of distributive rules that specify the communication of content and also performs the monitoring function of adequate understanding of the pedagogic discussion (Bertram, 2012, p. 6). These rules encompass the following three fields of knowledge. In production, the first field of knowledge, new knowledge is generated. In re-production, the second field of knowledge, the generated knowlegde is simplified and transformed into new pedagogic knowledge. In re-contextualisation, the third field of knowledge, the knowledge generated in the field of re-contextualisation is transformed for the second time for general consumption.

The production field of knowledge occurs at the highest level of education such as research centres institutes and universities. Therefore the knowledge generated in this field is esoteric and needs to be simplified, reshaped, re-organised and repackaged (Singh, 2002, p. 574) which occurs in the field of re-contextualisation. Institutional structures such as the DoE undertakes the process of re-contextualisation (Singh, 2002, p. 575). The field of reproduction generates the knowledge that is used by educators and learners. Ashwin (2014, p. 125) described the three fields of knowledge as "knowledge-as-research", "knowledge-as-curriculum" and "knowledge-as-student-understanding". These three fields are cyclic, and when applied as intended, the hope is that learners will eventually become part of the field of re-contextualisation and subsequently become part of the field of production. This study uses the field of re-contextualisation (curriculum) the field of re-production (assessment).

Hoadley and Jansen (2009, p. 171) described the curriculum as the product of knowledge organisation and further stated that the curriculum is concerned with the transfer of knowledge across three boundaries that exist, firstly between localised and specialised knowledge secondly, between specialisations and thirdly, within specialisations. These boundaries may be closed and have a clear distinction between knowledge areas, or they may be open and allow for the integration of knowledge areas (Hoadley *et al.*, 2009, p. 180).

Hinchliffe (2000, p. 31) contrasted pedagogy from education by stating that while education was a self-serving activity, pedagogy was as an activity, oriented towards social purposes.

Pedagogy consists of the following framing rules (Hoadley, 2006, p. 22): Selection which refers to the process of selecting content from the curriculum, sequencing which refers to the process of ordering the teaching content, pacing which refers to the process of establishing the time requirements for the learners, assessment which refers to the process of determining the degree to which learners have acquired the necessary knowledge, and relationships which refers to the connection between the educator and the learner.

In addition to determining the degree to which a learner has learned what the curriculum stipulates (Kahl, 2013, p. 2617), the assessment also provides a feedback mechanism (Hattie & Timperley, 2007, p. 102).

Figure 1 illustrates an assessment feedback loop in an education system. The input of an education system is the curriculum that is implemented using teaching and learning processes to produce the output of learned knowledge. The continuous improvement within an education system occurs if the feedback from assessments is used to enhance the curriculum. The shaded area of Figure 1 indicates the concepts that apply to this study.

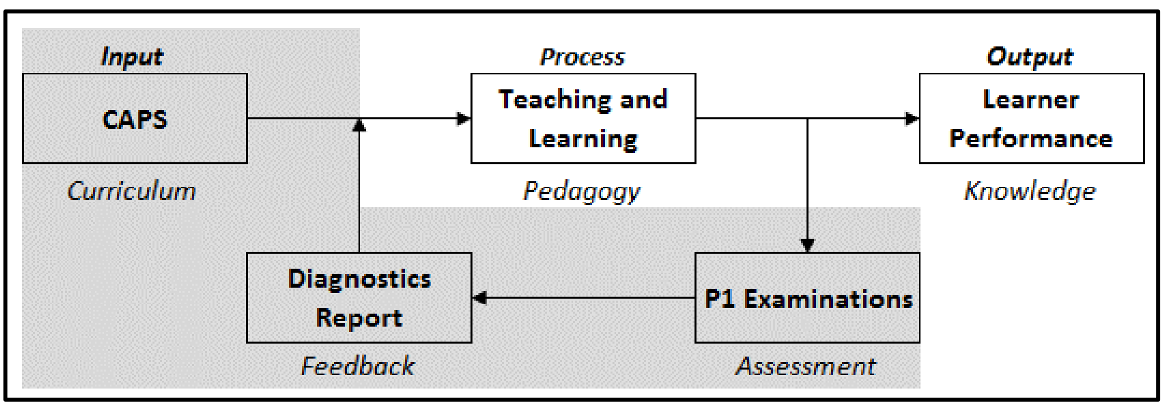


Figure 1. Feedback Mechanism of Assessment. Adapted from "The Power of Feedback" (Hattie *et al.*, 2007, pp. 81-112)

Hoadley (2006, p. 22) also stated that pedagogy consists of the following classifications rules: the strength of boundary between the subject area and other subject areas, the strength of boundary between the subject area and common knowledge, the strength of demarcation between spaces used by educators and learners, the strength of boundary between classroom space and learning, the strength of demarcation of pedagogic identities, and the strength of boundary between the subject area and other subject areas was used in this study and resulted in the use of the four topics of physics (Section 2.7).

Bloom (1956) created a scheme of classification that categorised the levels of reasoning skills (cognitive demand) required by learners. The purpose of Bloom's taxonomy was to develop a system of codification that could be used by educators to design a hierarchical organisation of learning outcomes. Bloom's taxonomy has six cognitive demand levels (CDL), which are knowledge, comprehension, application, analysis, synthesis, and evaluation. Figure 2 illustrates the cognitive levels in Bloom's taxonomy.

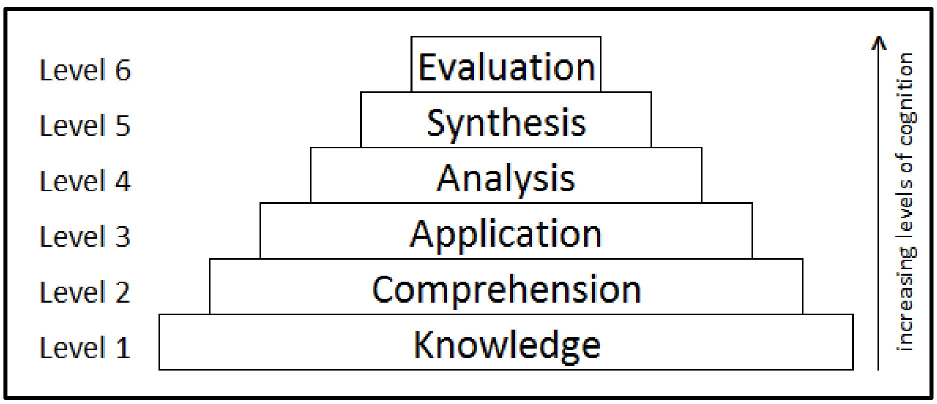


Figure 2. Levels of Cognitive Demand in Bloom's Taxonomy. Adapted from "A Revision of Bloom's Taxonomy: An Overview" (Krathwohl, 2002, p. 213).

Wlison (2016) defined the six levels of Bloom's taxonomy of the cognitive domain: Knowledge is described by information retrieval achieved either by recognition or recall; comprehension is described as the assimilation of new information by some form of communication. Application is described as the use of learnt knowledge in new conditions; analysis is described as the detection of relationships between the content and the source; synthesis is described as the creation of new educational structures to assist in effective communication; and evaulation is described as the process of decision making about the significance of knowledge.

The original Bloom's hierarchy is based on the presumption that learning is a sequential process and the hierarchy is presented as a simple view of how learners understand information. The hierarchy further assumes that the levels in the hierarchy corresponds to levels of thinking in which the higher levels of the taxonomy corresponds to higher order thinking skills, which are inherently more difficult than lower order thinking skills (Case, 2013, p. 198). In order to overcome this flaw of the taxonomy, educators of Physical Science must promote learners to participate in higher order thinking tasks, starting at a low level of difficulty and increasing the level of difficulty in accordance with the learner's aptitude.

Case (2013, p. 198) also states that the hierarchical taxonomy implies that learners are expected to understand concepts without requiring them to perform tasks involved in higher levels of the taxonomy such as "interpret, distinguish, relate or question". This leads to the argument that the learning of definitions in the exact words as described in the curriculum does not develop the understanding of the concepts in Physical Science.

Krathwohl (2002, p. 215) presented a revision to the original Bloom's taxonomy which was verb based rather than the noun based original taxonomy.

Figure 3 illustrates the revised Bloom's taxonomy that consists of six hierarchical levels of cognitive demand: remember, understand, apply, analyse, evaluate and create.

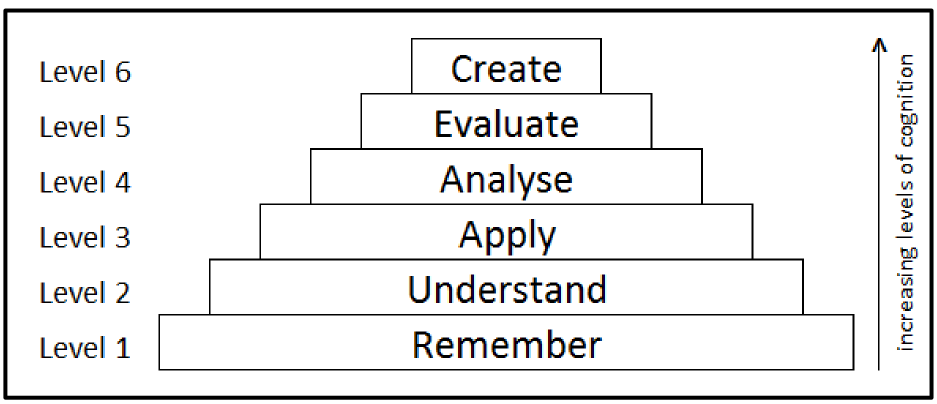


Figure 3. Revised Bloom's Taxonomy. Adapted from "A Revision of Bloom's Taxonomy: An Overview" (Krathwohl, 2002, p. 215).

The problem with the verb based taxonomy is a misconception that each verb explicitly describes the thinking involved in performing a task. This is evident in the "evaluate" level of the taxonomy. As a level on its own, this implies that there are no evaluative components linked to any other level, which is clearly not the case (Case, 2013, p. 200). The misconception that each level of the taxonomy is independent of the other is a flaw of the revised Bloom's taxonomy.

Figure 4 illustrates the modified version of Bloom's taxonomy. This taxonomy is presented in the Guidelines 2017 (DBE, 2017c, p. 5). Unlike the original and the revised Bloom's taxonomy, the modified taxonomy is not hierarchical. The linear nature of the modified taxonomy is evident as a learner may be able to apply a principle (Level 3) without having any degree of comprehension in it (Level 2).

Recall	Comprehension	Application and analysis	Synthesis and evaluation
Level 1	Level 2	Level 3	Level 4

Figure 4. Cognitive Demand Levels in the Modified Bloom's Taxonomy. Adapted from "Physical Sciences Examination Guidelines Senior Certificate Grade 12 2017" (DBE, 2017c, p. 5). In the public domain.

The modified cognitive taxonomy consists of four levels of cognitive demand: recall; comprehension; application and analysis; and synthesis and evaluation. The third cognitive demand level in the modified cognitive taxonomy is a combination of level three and level four of the original taxonomy. Likewise, the fourth cognitive demand level is a combination of level five and level six of the original taxonomy.

This study is framed based on the theoretical principles of Bernstein's pedagogic device and Bloom's taxonomy of cognitive demands. The cognitive demand level of the content of the CAPS belongs to the field of production, and the cognitive demand level of the P1 belongs to the field of re-contextualisation. illustrates the theoretical framework used in this study.

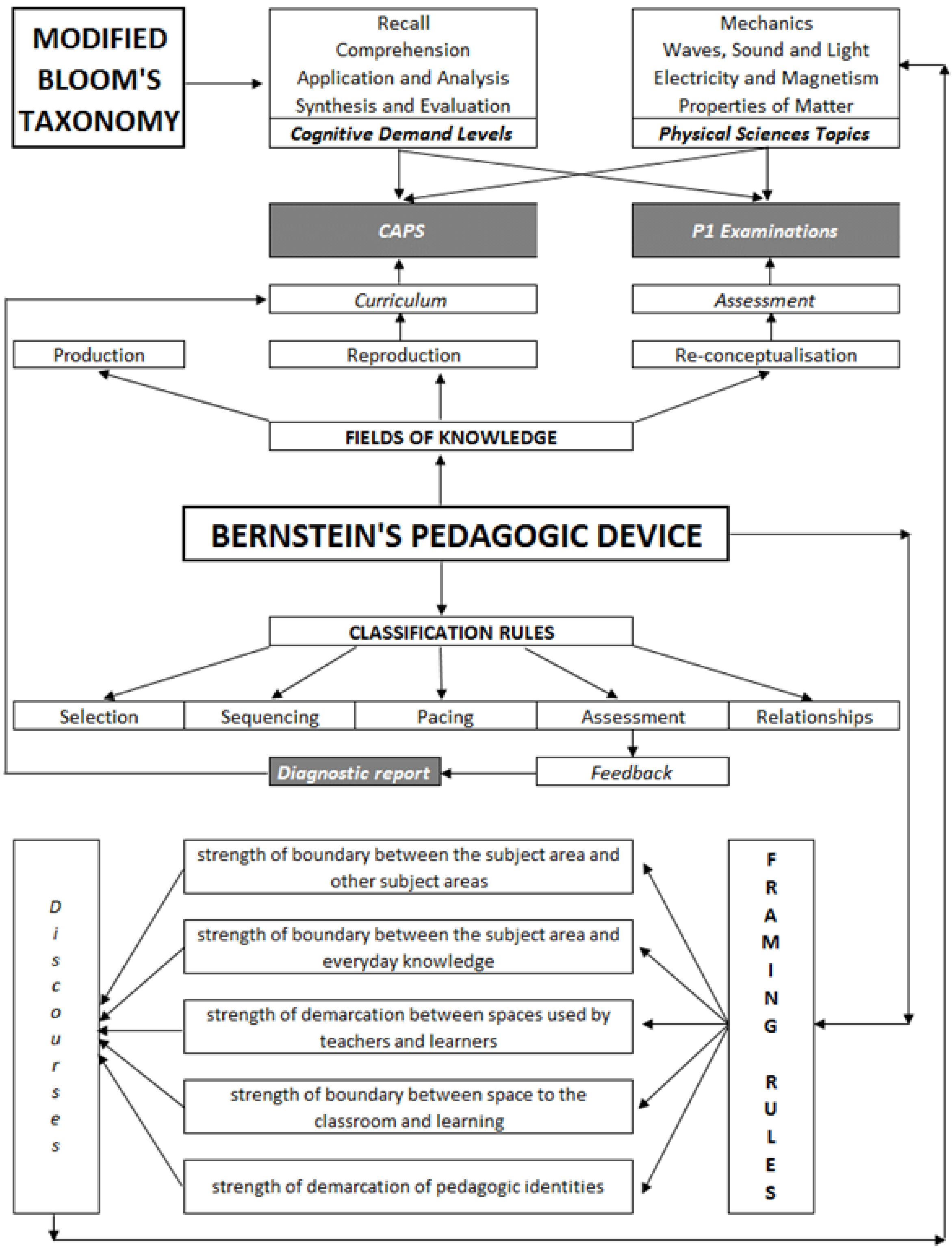


Figure 5. Theoretical Framework. Adapted from "Pedagogising Knowledge: Bernstein's Theory of the Pedagogic Device" (Singh, 2002, pp. 571-582).

2.3 CONTEXT OF THE SOUTH AFRICAN EDUCATION SYSTEM.

2.3.1 Department of Basic Education Grade Structure.

The Department of Basic Education (DBE) is a government organisation responsible for the undertaking of teaching and learning activities in schools, early learning centres, and special needs schools. (DBE, 2017a). Table 1 shows the breakdown of the educational structure currently being used by the DBE.

Table 2

Department of Basic Education Grade Structure (Grades 0 – 12)

Band	Phase	Grades	Curriculum
	Foundation	0, 1, 2, and 3	
GET	Intermediate	4, 5, and 6	Natural Sciences and Technology
	Senior	7,8, and 9	Natural Sciences
FET	Further Education and Training	10, 11, and 12	Physical Sciences

Note. From “National Department of Basic Education” (DBE, 2017a). In the public domain. GET, General Education and Training. FET, Further Education and Training.

There are two bands of education levels under the governance of the DBE. The General Education and Training (GET) band comprises three phases. The first phase is the Foundation phase which includes Grade 0 to Grade 3. The second phase is the Intermediate phase and includes Grade 4 to Grade 6. The third phase is the Senior phase and includes Grade 7 to Grade 9. The second band is known as the Further Education and Training (FET) phase and includes Grade 10 to Grade 12 (South African Qualifications Authority, 2000). The Intermediate phase of the GET band teaches Physical Sciences as part of the Natural Sciences and Technology curriculum until Grade 6 (DBE, 2011a). The Senior phase of the GET band teaches Physical Sciences as part of the Natural Sciences curriculum until Grade 9 (DBE, 2011a). The DBE introduced a CAPS Physical Sciences curriculum in Grade 10 of the FET phase (DBE, 2011b).

2.3.2 The National Senior Certificate Qualification.

According to the DBE (2018c), the Grade 12 qualification is the National Senior Certificate (NSC). The subject requirement for the NSC is a minimum of seven subjects in the FET Phase (DBE, 2018c). Four of the seven subjects are fundamental subjects, and three are elective subjects. The fundamental subjects comprised of a home language, an additional language, life orientation, and mathematics or mathematics literacy. Three elective subjects are chosen from a list of subjects approved by the DBE. Grade 12 Physical Sciences is an elective subject.

The final Grade 12 Physical Sciences examinations are written in November each year. Umalusi (2017, p. 10) described particular conditions under which learners may be allowed to write the supplementary examination in February/March of the following year.

2.3.3 The Curriculum Changes in South Africa.

After the 1994 democratic elections, the Department of Education (DoE) inherited an education system that had social, economic and political imbalances (Schmidt, 2017, p. 370). In an attempt to address these imbalances, the DoE developed an educational standard formulated on an Outcomes Based Education (OBE) policy (Jansen, 1998, p. 321). The DoE launched Curriculum 2005 (C2005) in 1997 and implemented it in 1998. One of the aims of the C2005 was to address the social imbalances created by the apartheid regime (Harley & Wedekind, 2004, p. 213). In an attempt to achieve this aim, the C2005 focused more on broader issues rather than on the educational content of the curriculum which resulted in a failing education system. Some of the reasons suggested by Jansen (1998) for the failure of C2005 were that the prerequisites for a curriculum change were not in place, the inadequacy of resources required by schools, the OBE policy undermined the vulnerable teaching culture and increased the administration burden on the education system, and the lack of buy-in from educators of the continuous assessment policies of C2005.

The failure of C2005 prompted a revision of the curriculum in 2000 (Chisholm, 2005, p. 193). The revision of the C2005 in 2000 produced the Revised National Curriculum Statements (RNCS) Grades R – 9 and a second review of the C2005 in 2002 produced the National Curriculum Statements (NCS) Grades 10 – 12. The first NSC examination based on the NCS

Grades 10 – 12 was written in November 2008. In 2012, the RNCS Grades R – 9 and the NCS Grades 10 – 12 were combined to produce the NCS Grade R – 12.

The NCS was an outcomes-based education system which comprised of the policy statements for teaching and learning in South African schools. The NCS for Physical Sciences comprised of the NCS for Grades 10 – 12: Physical Sciences, the NCS for Grades 10 – 12: Learning Programme Guidelines – Physical Sciences, the NCS for Grades 10 – 12: Subject Assessment Guidelines – Physical Sciences, the NCS for Grades 10 – 12: Physical Sciences Examination Guidelines, the NCS for Grades 10 – 12: Physical Sciences Content Document, and the NCS for Grades 10 – 12: Overview Document (Department of Education, 2006).

Five of the six documents above are subject related while the Overview Document is a general document applicable to all subjects. The principal reason for the implementation problem of the NCS was the administrative load experienced by educators and administrators. A revision of the NCS produced the current Curriculum Assessment Policy Statement (CAPS) Grades R – 12. The CAPS Grades R – 12 includes a set of four policy documents (Grussendorff, Booyse, & Burroughs, 2014, p. 94) that was implemented across all grades by 2014 (DBE, 2015b, p. 4). Learners wrote the first Curriculum Assessment and Policy Statement based Grade 12 Physical Sciences examinations in November 2014.

A summary of the changes that the South African education curriculum evolved through was:

1995 – Existing syllabi removed of race and gender stereotypes.
1996 – Development of learning outcomes.
1997 – Select schools piloted the C2005.
1998 – C2005 implementation into Grade 1.
1999 – C2005 implemented into Grade 2.
2000 – C2005 was implemented nationally for other grades in the GET phase.
2001 – C2005 revision to RNCS Grades R – 9.
2002 – RNCS Grades R – 9 published.
2003 – RNCS educator training begins.
2005 – RNCS Grades R – 9 implemented for the GET phase.
2006 – NSC Grades 10 – 12 implemented for the FET phase.

2008 – First Grade 12 OBE based examination.

2009 – Review of NCS implemented.

2010 – CAPS Grades R – 12 created.

2011 – CAPS Grades R – 12 educator training implemented.

2012 – CAPS Grades R – 12 implemented in the Foundation Phase and Grade 10.

2013 – CAPS Grades R – 12 implemented in the Intermediate Phase.

2014 – CAPS Grades R – 12 implemented in the Senior Phase.

This study focuses on the starting period as November 2014 when the first CAPS based Grade 12 Physical Sciences was written.

2.3.4 The Documentation of the CAPS based Physical Sciences.

According to Grussendorff *et al.* (2014, p. 38), the documents of the CAPS FET Phase Physical Sciences included the CAPS FET Phase Grades 10 – 12 Physical Sciences document, the Examination Guidelines Physical Sciences Grade 12 document, the National Policy Pertaining to the Programme and Promotion Requirements of the NCS Grades R – 12 document, and the National Protocol for Assessment Grades R – 12 document.

The CAPS FET Grades 10 – 12 Phase Physical Sciences document and the Examination Guidelines Physical Sciences Grade 12 (Guidelines) are subject related documents while the National Policy Pertaining to the Programme and Promotion Requirements of the NCS Grades R – 12 and the National Protocol for Assessment Grades R – 12 are not subject related documents. The use of Physics in this study refers to the physics discipline of the FET Phase Physical Sciences and the use of CAPS in this study refers to the combined Grade 12 Physics content of the CAPS FET Phase Grades 10 – 12 Physical Sciences document and the Guidelines document.

2.3.5 Physics Topics and Teaching.

Physical Sciences comprise two disciplines, namely physics and chemistry. The physics discipline incorporates subject matter in the mechanics; waves, sound and light; electricity and magnetism; and optical phenomena topics. The chemistry discipline incorporates subject matter in matter and materials, chemical change and chemical systems (DBE, 2011b, p. 13). Table 3 lists the teaching time spent on the individual topics of physics and shows that the teaching time for mechanics is most substantial.

Table 3

Teaching Time for Physics

Physics topic	Teaching time (hours)	Percent
Mechanics	17.50	53.8
Waves, sound and light	3.75	11.5
Electricity and magnetism	7.50	23.1
Optical phenomena	3.75	11.5
Total	65.00	100.0

Note. From "Curriculum and Assessment Policy Statement Grades 10 – 12 Physical Sciences" (DBE, 2011b, p. 13). In the public domain.

Table 3 also shows that the teaching time allocated to electricity and magnetism is half that of mechanics and the teaching allocated to waves, sound and light, as well as optical phenomena, is almost a fifth of the teaching time allocated to mechanics.

The spiral nature of a curriculum refers to the process in which Grade 12 examinations tests learners on Grade 10 and Grade 11 knowledge. The spiral nature of the CAPS design may explain the significant variance in allocated teaching time (Section 2.3)

2.3.6 The Assessment Components in Physical Sciences.

The Grade 12 Physical Sciences examination comprised two examination papers namely, the NSC Grade 12 Physical Sciences: Physics Paper 1 (P1) and the NSC Grade 12 Physical Sciences: Chemistry Paper 2 (P2). The Physical Sciences school-based assessment (SBA) comprises of class tests, midyear examinations, trial examinations, and three prescribed experiments, conducted as formal assessments (DBE, 2011b, p. 144).

Table 4 shows the components of the Grade 12 Physical Sciences assessments. The Grade 12 Physical Sciences examination comprises of 400 marks. Each of the P1 and P2 accounts for 150 marks having a duration of 3 hours. The SBA accounts for the remaining 100 marks.

Table 4

Assessment Components of Physical Sciences

Assessment component	Description	Mark	Weight
School Based Assessment	Control test	10	25%
	Mid-year examination	20	
	Trial examination	25	
	Practical assessments	45	
NSC Grade 12 Physical Sciences: Physics	Final examination	150	75%
NSC Grade 12 Physical Sciences: Chemistry	Final examination	150	
Total		400	100%

Note. From "CAPS FET Phase Grades 10 – 12 Physical Sciences" (DBE, 2011b, p. 148). In the public domain. Weight expressed as a percentage of 400 marks. NSC, National Senior Certificate.

Table 5 shows that a chemistry practical experiment in term one, a choice between a chemistry or a physics practical experiment in term two and a physics practical experiment in term three are conducted in Grade 12 Physical Sciences.

Table 5

Practical Experiments for Physical Sciences

Term	Discipline	Practical experiment topic	Mark
1	Chemistry	The preparation of esters.	15
2	Physics OR Chemistry	The conservation of Linear Momentum. The titration of oxalic acid against sodium hydroxide.	15
3	Physics	The internal resistance of a battery. The equivalent resistance of series and parallel networks.	15

Note. From "Physical Sciences School Based Assessment Exemplars – CAPS Grade 12 Teacher Guide" (DBE, 2017d, p. 3). In the public domain. Mark (column 4) contributed towards the total mark of 400 for Grade 12 Physical Sciences.

2.3.7 The Grade 12 Physical Sciences Learner Performance.

The pass mark for Grade 12 Physical Sciences is a final mark of at least 30 percent (DBE, 2018b, p. 6). In 2017, 179,561 students wrote the November 2017 Grade 12 Physical Sciences examinations and the pass rate was 65.1 percent (DBE, 2018a, p. 175).

Table 6 shows the performance data of the Grade 12 Physical Sciences November examinations for the period 2014 to 2017. The number of learners that wrote in 2017 was 6.8 percent less than 2016 while the pass rate increased by 3.1 percent.

Table 6

Physical Sciences Pass Rates

Examination	Learners wrote	>30%	>40%
November 2014	167,997	61.5%	36.9%
November 2015	193,189	58.6%	36.1%
November 2016	192,618	62.0%	39.5%
November 2017	179,561	65.1%	42.2%

Note. From "National Senior Certificate Examination 2017 Diagnostic Report Part 1" (DBE, 2018a, p. 175). In the public domain. The pass mark for Grade 12 Physical Sciences is 30 percent (column 3).

2.3.8 The NSC Examination Diagnostic Report Physical Sciences.

The NSC Examination Diagnostic Report (EDR) is an annual report issued by the DBE. The report that serves as a tool for improving teaching and learning in the 11 key NSC Grade 12 subjects: accounting, agricultural sciences, business studies, economics, English first additional language, geography, history, life sciences, mathematics, mathematical literacy and Physical Sciences. The EDR analyses learner performance and highlights areas of weakness; it also provides suggestions on remedial measures that may improve learner performance (DBE, 2018a). The EDR 2014 (DBE, 2015a) made two references to CAPS. The first reference made was to the practical experiments prescribed by the CAPS. The report suggested that learners could enhance their skills such as data analysis by performing the practical experiments of the SBA. The second reference made was to organic molecules prescribed by the CAPS. The EDR 2014 suggested firstly, the preparation of a laboratory guide for educators, and secondly, educators must attend workshops to improve their practical skills required for experiments and investigations (DBE, 2015a, p. 224).

The EDR 2015 (DBE, 2016a) made one reference to the CAPS regarding the inability of learners to simplify electrical circuits in the examination. The report urged learners to conduct practical experiments on electric circuits as prescribed by the CAPS to improve their understanding of electric circuits (DBE, 2016a, p. 184).

The EDR 2016 (DBE, 2017b) made two references to the CAPS. The first reference made was to discrepancies observed in the use of physics definitions: learners did not precisely match the definitions as described in the CAPS. Examples of these discrepancies were the use of the term "force" rather than "net force" and the use of the term "indirectly proportional" rather than "inversely proportional" (DBE, 2017b, p. 182). The EDR 2016 suggested that learners were required to use the precise definitions as described in the CAPS. The second reference made to the CAPS was a suggestion that learners need to perform practical experiments to improve the understanding of how electric circuits work (DBE, 2017b, p. 184).

The EDR 2017 (DBE, 2018a) made one reference to the CAPS regarding the inability of learners to state definitions and laws precisely as described in the CAPS. A suggestion to improve the learner's ability of recall may be achieved by the administration of informal assessments such as pop quizzes to strengthen the learners long term memory of definitions (DBE, 2018a, p. 185).

Table 7 shows the references made by the EDR to the CAPS.

Table 7

Physical Sciences Examination Diagnostic Feedback Summary

Document	Reference made to CAPS Grade 12 Physics
EDR 2014 (DBE, 2015a, p. 224)	Practical experiments and organic molecules.
EDR 2015 (DBE, 2016a, p. 184)	Practical experiments.
EDR 2016 (DBE, 2017b, p. 184)	Definitions and practical experiments.
EDR 2017 (DBE, 2018a, p. 185)	Recall ability of definitions.

Note. In the public domain. DBE, Department of Basic Education. EDR, Examination Diagnostic Report.

2.3.9 Alignment in Education.

The components of a well-aligned education system must be organised around a specific goal. The components have their own purpose and their interaction with other components within the system must benefit the system as a whole (Wilson & Bertenthal, 2005, p. 5). Mhlolo *et al.* (2009, p. 35) explained this as: the educational components of a system must work independently while also working as a group to achieve the goal of the system. Examples of components in an education system are the curriculum, teaching, and the examinations. Alignment within an education system refers to the degree to which these components are in agreement with each other (Rothman, Slattery, Vranek, & Resnick, 2002, p. 9). Webb (1997, p. 4) elaborated on this by stating that the alignment between the examination and the curriculum is the degree to which they guide the learner to learn what they need to know.

Martone *et al.* (2009, p. 1337) identified the Webb method, the Achieve method and the Surveys of Enacted Curriculum (SEC) method as the three most popular methods for alignment studies. Section 2.11.3 discussed the reasons for the use of the SEC alignment method in this study. The SEC method requires a classification of each content item of the CAPS and each question of the P1 according to the depth and breadth of the documents analysed. The depth of the CAPS and the P1 refers to the four levels of the modified cognitive taxonomy which are recall; comprehension; application and analysis; and synthesis and evaluation (Section 2.7). The breadth of the CAPS and P1 refers to the four topics of physics which are mechanics; waves, sound and light; electricity and magnetism; and optical phenomena (Section 2.6). A quantitative measure of alignment, the alignment index (AI) was used to determine the alignment between the CAPS and the P1 (Section 3.8.1). The AI ranges between zero and one with an AI closer to one indicating a stronger alignment.

2.3.10 Alignment Studies.

Studies that have calculated the alignment between the curriculum and the assessment for Grade 12 Physics or equivalent have been conducted by G. Fulmer, Kim, Liu, Liang, Yuan, and Zhang (2009) for New York, China, and Singapore, Guo, Xing, Xu, and Zheng (2012) for the Guangdong, Hainan, Ningxia and Shandong Provinces in China, and Edwards (2010) for South Africa.

Table 8 shows the AI calculated by each of these studies.

Table 8

Curriculum and Assessment Alignment Global Studies

Study	Location of study	AI
G. Fulmer *et al.* (2009, p. 787)	New York State	0.80
	Jiangsu Province China	0.67
	Singapore	0.67
Guo *et al.* (2012, p. 38)	Guangdong Province China	0.38
	Hainan Province China	0.30
	Ningxia Province China	0.25
	Shandong Province China	0.27
Edwards (2010, p. 586)	South Africa	0.80

Note. AI, Alignment index.

In the study by G. Fulmer *et al.* (2009, p. 787) New York had a significant alignment between the curriculum and the examination while China and Singapore did not. The reasons provided for the low alignment in China and Singapore was a shift towards higher order thinking skills in the examination that was not in the curriculum. A shift towards higher thinking cognitive skills in the examination could be the case for the alignment between the CAPS and the P1.

In the study by Guo *et al.* (2012) the alignment indices ranged between 0.27 and 0.38, which represented a low alignment between the curriculum and the examination. The reason provided for the lack of alignment was the introduction of a new curriculum. A change of curriculum could be the case for the lack of alignment between the P1 November 2014 and the P1 due to the introduction of the CAPS, in that year.

The study by Edwards (2010) was the first that quantified the alignment between the curriculum and the examination for Physical Sciences in the South African context. It included the analysis of the NCS curriculum, the NSC Grade 12 Physical Sciences: Physics (P1) and NSC Grade 12 Physical Sciences: Chemistry (P2). Three examinations were analysed in the study: P1 and P2 Exemplar 2008, P1 and P2 November 2008, and P1 and P2 November 2009. Edwards (2010, p. 581) calculated an average AI of 0.7830 for the alignment of the NCS and P1. Edwards (2010,

p. 587) also stated that a low AI is not necessarily harmful if it is due to the examination questions containing a higher cognitive demand than the curriculum prescribes.

2.4 THE CURRICULUM AND ASSESSMENT POLICY STATEMENT.

The pedagogic approach of a curriculum design describes the method of teaching and learning. As a learner-centred approach, there is less emphasis on the quantity of knowledge acquired and more emphasis on the engagement of knowledge through problem-solving and inquiry (Cunningham, Gannon, Kavanagh, Greene, Reddy & Whitson, 2007, p. 11).

The CAPS Grade R – 12 follows a learner-centred and a content-driven pedagogic approach that has clear educator guidelines throughout the document (Cobbinah & Bayaga, 2017, pp. 1637-1638). The CAPS does not state specific roles of the educator and the learner (Grussendorff *et al.*, 2014, p. 69) but describes the educator as the originator and facilitator of learning (Grussendorff *et al.*, 2014, p. 21). The learner is responsible for acquiring knowledge (Grussendorff *et al.*, 2014, p. 36). The CAPS encourages a critical and active approach to learning that is evident by the full range of practical activities including experiments, problem-solving, projects, model building and report writing (Grussendorff *et al.*, 2014, p. 116).

2.5 THE DESIGN OF THE CAPS FET GRADE 10 – 12 PHYSICAL SCIENCES.

The design of the CAPS FET Phase Grades 10 – 12 Physical Sciences was essential to this study due to the spiral approach of its design which was based on Bruner's theory of cognitive development (Saracho, 2017, p. 34). Harden (1999, p. 141) describes the spiral approach as the method of fragmenting a compound concept into simpler, comprehensible components. The simple concepts are then learned individually by constant reinforcement over a more extended period. The culmination of this approach was the comprehension of the original compound concept.

An example of the spiral approach of the CAPS FET Phase Grades 10 – 12 Physical Sciences design occurs in electric circuits. The concepts introduced in Grade 10 electric circuits were: electromotive force, potential difference, current and resistance (DBE, 2011b, pp. 42 - 45). The concepts introduced in Grade 11 electric circuits were: Ohms law and the power and energy of electric circuit components (DBE, 2011b, pp. 88 - 89). Ohm's law examination questions for Grade 11 electric circuits required Grade 10 knowledge of electric circuits. The concept introduced in Grade 12 electric circuits is internal resistance (DBE, 2011b, p. 129). The examination questions for Grade 12 electric circuits required the knowledge of Grade 10 and Grade 11 electric circuits. Table 9 shows the concepts of electric circuits in the spiral design of the CAPS FET Phase Grades 10 – 12 Physical Sciences.

Table 9

Spiral Design of the CAPS Grade 10 – 12 Physical Sciences

Grade	Concepts	Previous knowledge required
10	EMF, potential difference, current, resistors in series and parallel.	
11	Ohm’s law; electrical energy; electrical power.	Grade 10
12	Internal resistance.	Grade 10 and Grade 11

Note. Adapted from “Curriculum and Assessment Policy Statement Grades 10 - 12 Physical Sciences” (DBE, 2011b). In the public domain.

2.6 DEPTH OF TOPICS IN THE CAPS.

The depth of topics in the CAPS is the level of cognitive complexity that the CAPS provides to each physics topic. It was important to study each level of the modified cognitive taxonomy in detail so that the classification accurately represented the cognitive demand of the CAPS and the P1.

The four levels of cognitive demand in the modified cognitive taxonomy are:

- Cognitive demand level 1 (CDL1) – recall.
- Cognitive demand level 2 (CDL2) – comprehension.
- Cognitive demand level 3 (CDL3) – application and analysis.
- Cognitive demand level 4 (CDL4) – synthesis and evaluation.

2.6.1 Cognitive Demand Level 1 (CDL1) – Recall.

The first level of the modified cognitive taxonomy is recall. In cognitive demand level 1 (CDL1), knowledge is acquired as disconnected facts by the method of rote learning (P. Zhang, Ding, & Mazur, 2017, p. 2). A learner must be able to remember, recall, and restate facts and information (Haridza & Irving, 2017, p. 6) with relative ease. CDL1 assessment questions test the learners' ability to recall, recognise, reproduce or execute basic physics knowledge related to the question (Bhuyan, Khan, & Rahman, 2018, p. 7). CDL1 assessment questions required a correct answer without incurring a significant error. Thus an understanding of how the procedure works is not required (Maknun, 2017, p. 2). Examples of P1 examination questions based on CDL1 are: Name the instrument used to measure potential difference; state Newton's law of universal gravitation; and define inertia.

2.6.2 Cognitive Demand Level 2 (CDL2) – Comprehension.

The second level of the modified cognitive taxonomy is comprehension. In cognitive demand level 2 (CDL2) the ability of learners to understand concepts in physics by integrating, identifying and categorising characteristics of the assessment question (Horváthová, Rakovská, & Zelenický, 2017, p. 4). Shao (2018) referred to this understanding of assessment questions as the testing of procedures without any connections. Assessment questions based on CDL2 also involved the construction of an exact picture of the knowledge or a procedure needed to solve problems in physics (Opfermann, Schmeck, & Fischer, 2017, p. 14). Examples of P1 questions based on CDL2: Distinguish between the dependent and independent variables; use the graph and read off the velocity at t = 5 seconds, and classify the collision as elastic or inelastic.

2.6.3 Cognitive Demand Level 3 (CDL3) – Application and Analysis.

The third cognitive demand level of the modified cognitive taxonomy is application and analysis. In cognitive demand level 3 (CDL3), learners may have to modify known information in a manner suiting the requirements of the questions to solve problems within new situations. Assessment questions based on CDL3 involves the learner identifying relationships between the physics problem components and the categories of physics problems (Bhuyan *et al.*, 2018,

p. 7). Assessment questions based on CDL3 tests the ability of learners to apply physics knowledge in solving problems and analyse concepts in physics.

CDL3 based assessment questions include application as well as analysis type assessment questions. In CDL3 application type assessment questions, the learner applies knowledge and skills both in situations familiar and new and in CDL3 analysis type assessment questions, the learner makes a careful assessment of the question to obtain an answer (Bhuyan *et al.*, 2018, p. 7). Examples of P1 assessment questions based on CDL3: Calculation the final velocity of the trolley; draw a fully labelled free-body force diagram of the stationary object; from given the displacement-time graph, sketch a corresponding velocity-time graph.

2.6.4 Cognitive Demand Level 4 (CDL4) – Synthesis and Evaluation.

The fourth cognitive demand level of the modified cognitive taxonomy is synthesis and evaluation. Assessment questions based on cognitive demand level 4 (CDL4) involves the learner having the ability to utilise physics knowledge and not only be able to select but also explain the selection between two or more alternatives (Bhuyan *et al.*, 2018, p. 8). The learner must have the ability to solve problems by performing tasks which may not be familiar or may require a complex solution, engaging a higher level of thinking and not just an application of conceptual or procedural knowledge.

Assessment questions based on CDL4 include synthesis type as well as evaluation type assessment questions. In CDL4 synthesis type assessment questions, new knowledge is created using pre-acquired knowledge from relationships and abstract ideas. Evaluation type assessment questions requires a personal assessment at the abstract level of the situation. Questions based on evaluation makes connections within the acquired knowledge beyond the subject area. An application of principles and ideas are made to generalised situations (Bhuyan *et al.*, 2018, p. 8). Evaluation type questions test the ability to relate physics to everyday situations. Examples of P1 assessment questions based on CDL4: Design a 5V battery with a capacity of 30Ah having negligible internal resistance; Devise an experiment to determine the gravitational acceleration constant; and has the experiment been successful in enabling the validating the hypothesis?

Table 10 lists the skills demonstrated at each level of the modified cognitive taxonomy.

Table 10

Cognitive Demand Level Skills

Recall	Comprehension	Application and analysis	Synthesis and evaluation
describing	classifying	carrying out	designing
identifying	comparing	executing	devising
listing	exemplifying	implementing	generating
naming	explaining	using	inventing
recalling	inferring	attributing	making
recognising	interpreting	comparing	planning
retrieving		deconstructing	producing
		finding	checking
		integrating	critiquing
		organising	detecting
		outlining	experimenting
		structuring	hypothesising
			judging
			monitoring
			testing

Note. Adapted from "A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives" (Anderson, Krathwohl, & Bloom, 2001).

Table 11 lists the verbs in each level of the modified cognitive taxonomy.

Table 11

Cognitive Demand Level Verbs

Recall	Comprehension	Application and analysis	Synthesis and evaluation
cite	classify	analyze	advise
define	compare	apply	arrange
identify	convert	appraise	assemble
label	deduce	calculate	combine
list	defend	categorize	compose
locate	describe	choose	construct
match	discuss	classify	create
memorize	distinguish	compare	criticize
name	estimate	contrast	design
recall	explain	demonstrate	develop
recite	express	differentiate	devise
record	extend	divide	formulate
repeat	generalize	draw	generate
reproduce	locate	examine	invent
select	paraphrase	illustrate	modify
state	predict	infer	organize
	report	interpret	plan
	restate	point out	prepare
	review	reason	produce
	rewrite	relate	rate
	summarize	show	validate
	translate	sketch	write
		solve	
		test	
		which	

Note. Adapted from "Re-evaluating Bloom's Taxonomy: What Measurable Verbs Can and Cannot Say about Student Learning" (Stanny, 2016, p. 37).

2.7 BREADTH OF THE CAPS.

The breadth of the CAPS refers to the content coverage of the CAPS. There are four topics in Grade 12 Physics are mechanics; waves, sound and light; electricity and magnetism; and optical phenomena. Within these four topics, there are 29 knowledge content subtopics. The content coverage included the following four Grade 12 Physics topics (DBE, 2011b, p. 8) are:

- Physics topic 1 (PST1) – mechanics (14 subtopics).
- Physics topic 2 (PST2) – waves, sound and light (3 subtopics).
- Physics topic 3 (PST3) – electricity and magnetism (10 subtopics).
- Physics topic 4 (PST4) – optical phenomena (2 subtopics).

2.7.1 Physics Topic 1 (PST1) – Mechanics.

According to the DBE (2011b, p. 10) the Grade 12 Physics knowledge content subtopics for mechanics are resultants of perpendicular vectors, resolution of a vector into its components, force diagrams and free body diagrams, Newton's laws of motion, Newton's law of universal gravitation, momentum, conservation of momentum, elastic and inelastic collisions, impulse, vertical projectile motion in one dimension, definition of work, the work-energy theorem, non-conservative forces, and mechanical power.

2.7.2 Physics Topic 2 (PST2) –Waves, sound and light.

According to the DBE (2011b, p. 10), the Grade 12 Physics knowledge content subtopics for waves, sound and light are sound and ultrasound, redshifts in the universe, and applications of the Doppler effect.

2.7.3 Physics Topic 3 (PST3) – Electricity and magnetism.

According to the DBE (2011b, p. 10), the Grade 12 Physics knowledge content subtopics for electricity and magnetism are Coulomb's law, electric fields, magnetic fields around current carrying conductor, Faraday's law, Ohm's law, electrical energy and power, series and parallel circuit networks, internal resistance, electrical generators and motors, and alternating current.

2.7.4 Physics Topic 4 (PST4) – Optical Phenomena.

According to the DBE (2011b, p. 10), the Grade 12 Physics knowledge content subtopics for optical phenomena are the photo-electric effect; and emission and absorption spectra.

THE PHYSICAL SCIENCES EXAMINATION GUIDELINES GRADE 12.

According to the DBE (2017c, p. 3), the purpose of the Guidelines was first, to provide clarity
2.8 on the concepts & skills of the CAPS, assessed in the P1 and second, a tool that assists educators
in preparing learners for the P1.

The Guidelines also contained information on the format of examination question papers, numbering and sequence of questions, information sheets, cognitive demand level weighting, the mark weighting of prescribed content, skills required in Physical Sciences, prior knowledge required from Grade 10 and Grade 11, elaboration of content for Grade 12 Paper 1: Physics Grade 12 Paper 2: Chemistry, use of quantities, symbols and units, sign conventions, symbols, terminology and nomenclature usage as well as the marking guidelines.

2.8.1 Physics Topic and Cognitive Demand Weighting in the Guidelines.

The physics topic weighting of the P1 in the Guidelines is mark based, while the cognitive demand weighting is based on the number of questions in the P1 (DBE, 2017c, p. 5). Table 12 shows the physics topic weighting and Table 13 shows the cognitive demand weighting both, as described in the Guidelines 2017. The topic and cognitive demand weighting described in the Guidelines 2017 did not change from the weighting described in the Guidelines of the previous three years (DBE, 2014b, 2015c, 2017c; South African Comprehensive Assessment Institute, 2016).

Table 12 shows that the mechanics topic is the highest weighted followed closely by the electricity and magnetism topic. The waves, sound and light topic and the optical phenomena topic are weighted almost a third of the higher weighted topics. Table 13 shows that the application and analysis cognitive demand is the highest weighted. The synthesis and evaluation cognitive demand is the lowest weighted. The recall cognitive demand is weighted less than half of both the application and analysis cognitive demand and the comprehension cognitive demand.

Table 12

NSC Physics Examination Topic Weighting

Physics topic	PST code	Weighting
Mechanics	1	42%
Waves, sound and light	2	11%
Electricity and magnetism	3	37%
Optical phenomena	4	10%

Note. From "Physical Sciences Examination Guidelines Senior Certificate Grade 12 2017" (DBE, 2017c, p. 5). In the public domain. PST, physics topic.

Table 13

NSC Physics Examination Cognitive Demand Weighting

Cognitive demand level	CDL code	Weighting
Recall	1	15%
Comprehension	2	35%
Application and analysis	3	40%
Synthesis and evaluation	4	10%

Note. From "Physical Sciences Examination Guidelines Senior Certificate Grade 12 2017" (DBE, 2017c, p. 5). In the public domain. CDL, cognitive demand level.

2.9 ALIGNMENT OF THE P1 AND THE CAPS.

The three primary components of an education system are the curriculum, assessments and teaching activities. For the proper functioning of an education system, the alignment between curriculum content and instructional activities with the assessment is required (Mhlolo *et al.*, 2009, p. 35). The alignment between the curriculum and the examination yields the examination validity, which is the degree to which interpretations made on the results of the examination can be considered accurate (Roach, Elliott, & Webb, 2005, p. 219).

TRADITIONAL METHODOLOGIES OF ALIGNMENT.

Traditional methodologies for determining the alignment between the curriculum and the examinations included sequential development, expert review and content analysis.

2.10 2.10.1 Sequential Development.

In sequential development, the curriculum is used to develop the examination sequentially. Each examination item is derived from the curriculum which results in an alignment by design (Roach, Niebling, & Kurz, 2008, p. 171).

2.10.2 Expert Review.

Expert review relies on the opinion of specialists in the field that are knowledgeable about the content covered in the curriculum (B. Case & Zucker, 2005, p. 3). The process of expert review includes an item by item review of each topic of the curriculum by a review panel. The review panel may consist of subject experts, administrators, educators, parents, and members of the public.

2.10.3 Content Analysis.

Content analysis requires a classification of subject domains and cognitive demands of the content of the curriculum and the questions of the examinations which allows for the analysed documents to be quantified and compared (Duruk, Akgüna, Doğanb, & Gülsuyuc, 2017, p. 127). In addition to a content match between the curriculum and the examination, this alignment
2.11 methodology includes a quantitative measure of alignment using of Porter’s equation (Traynor, 2014, p. 12).

RESEARCH METHODS IN ALIGNMENT STUDIES.

Research methods have been developed to attain a more sophisticated level of analysis of the components of an education system. The three most generally used methods are the Webb method (Webb, 1997), the Achieve method (Resnick, Rothman, Slattery, & Vranek, 2004) and the SEC method (Porter, Blank, & Smithson, 2001).

2.11.1 The Webb Method.

Webb's alignment method explores five dimensions of understanding alignment which are "the content focus, articulation across grades and ages, equity and fairness, pedagogical implications, and system applicability" (Webb, 1997, pp. 6-8). Each of these dimensions includes alignment criteria that were realised by a review of US national and state alignment studies (Webb, 1997, p. 5).

The content focus dimension includes six alignment criteria: "categorical concurrence, depth of knowledge consistency, the range of knowledge correspondence, the structure of knowledge comparability, the balance of representation, and dispositional concurrence" (Webb, 1997, pp. 6-7). The articulation across grades and ages dimension includes two alignment criteria: cognitive soundness determined by best research and understanding as well as increasing growth in knowledge during students' schooling (Webb, 1997, p. 7).

The equity and fairness dimension forms an alignment criterion itself and embraces the social construct of the education system (Webb, 1997, pp. 7-8). The pedagogical implications dimension includes two alignment criteria: engaging of students and effective classroom procedures as well as the use of materials, tools, and technology (Webb, 1997, p. 8). The system applicability dimension forms an alignment criterion itself and embraces the real world day to day application of systems within education (Webb, 1997, pp. 7-8).

2.11.2 Achieve Method.

The Achieve alignment method is a two-step process. The processes of the first step are the confirmation of a test blueprint, a determination of the content and performance centrality, evaluation of sources of challenge and determination of cognitive demand levels (Martone *et al.*, 2009, p. 1343). The processes of the second step are a complete evaluation of items matched to a central standard regarding the overall level of challenge, balance and range (Martone *et al.*, 2009, p. 1345). The five alignment criteria of the Achieve alignment model are content centrality and performance centrality from the first step of the model and challenge, balance and range from the second step of the Achieve alignment model.

2.11.3 Surveys of Enacted Curriculum Alignment (SEC) Method.

The SEC method requires a content topic and cognitive demand level classification of the curriculum and the examination. This classification produces a matrix that enables a comparison of the curriculum and the examination. According to Elliott *et al.* (2010, p. 132), the SEC method provides four measures of alignment. Categorical coherence which is a measure of matching topics, balance of representation which is a measure of the relative emphasis of topic coverage, cognitive complexity which is a measure of the relative emphasis of cognitive demand, and the alignment index which is a quantitative measure of the alignment.

The Webb method and the Achieve method are used to understand the subject coverage comparisons better, while the SEC method is used to get an understanding of both, the subject content and the cognitive demand between the curriculum and the examination (Edwards, 2010, p. 575). This study used the SEC method to determine the alignment between the CAPS and the P1. The reason for the use of the SEC method is that it provides a quantitative measure of alignment by an understanding of cognitive demand between the curriculum and the examination of one subject (Physical Sciences) in one grade (Grade 12) in the absence of any performance data.

2.12 SUMMARY OF CHAPTER TWO.

This chapter presented a theoretical basis to justify the purpose and also the methods used to carry out this study. This study uses Bernstein’s pedagogic device and Bloom’s taxonomy of cognitive domains as a framework. The literature reviewed included; the education system in South Africa; curriculum changes in South Africa; the CAPS curriculum; the breadth and depth of the CAPS; the NSC Physical Sciences: Physics (P1) examination; traditional alignment methodologies; and research methods in alignment studies. The next chapter presents the research design and the methodology used in this study.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

INTRODUCTION.

This chapter describes in detail the research design and methodology and outlines the research philosophy, research strategy, research approach, data collection methods, sample size
3.1 selection, research process, data analysis, ethical considerations and research limitations of this study.

RESEARCH PHILOSOPHY.

3.2 Thomas Kuhn (1977, p. 294) described a paradigm as a shared view of reality among the members of a scientific community, where they, were the only ones who shared this view and when this shared view of reality changes, reality itself changes. Guba and Lincoln (1994, p. 108) determined the three dimensions of a paradigm are firstly, what is the construct and nature of reality? (known as the ontology question), secondly, what is the relationship between the researcher and what can be known? (known as the epistemology question), and thirdly, how does the researcher find out whatever they believe can be known? (known as the methodology question).

Four research paradigms were presented by Wahyuni (2012, p. 70) including positivism, post-positivism, interpretivism and pragmatism. Based on the three dimensions of a paradigm, this study adopted a positivist position. The rational and empirical philosophies that originated with Aristotle is the basis for positivism which is sometimes also referred to as the “scientific method” or “science research” (Mertens, 1998, p. 8) and reflects a deterministic viewpoint which promotes causality (Creswell, 2003, p. 7). Positivism relates to the three dimensions of the paradigm are firstly, the ontology position of positivism assumes an impartial truth which one can methodically and logically study through investigation driven by fundamental principles applicable to human behaviour, secondly, the epistemological position of positivism assumes that the researcher and the phenomenon in question are independent. The independence of the researcher determines the validity of the research, hence the researcher needs to remain isolated, unbiased and impartial throughout the investigation, and thirdly, the methodological position of positivism purports the scientific method in which general theories are used to generate hypotheses, which are subjected to replicable empirical testing. Hypotheses should allow for verification provide the opportunity for acceptance and rejection.

The present study did not include the generation of hypotheses or instigated any empirical testing, and therefore cannot be strictly positioned as a positivistic paradigm. However, Shanks and Parr (2003, p. 1762) stated that: “paradigms are assumptions and were not subject to proof, they are human constructions that are neither right nor wrong: proponents must argue for their utility.” The argument for the use of a positivistic paradigm in this study is that the content analysis was performed using a list of verbs as the coding scheme and during instances of the absence of a verb in the list, a verb a substantively assigned. Using the list of verbs and assigned verbs, this study ensured objectivity and the capability to reproduce the results obtained if conducted by different researchers.

3.3 RESEARCH STRATEGY.

A research strategy is not a data collection method but promotes various methods for collecting data (Malliari & Togia, 2017, p. 813). Wahyuni (2012, p. 78) stated that research strategies provide a link between the research paradigm and the data collecting methods. Pellissier (2010) presented six research strategies: experiment, survey, case study, grounded theory, ethnography, and action research. Yin (1984, p. 23) defined the case study research method as: “an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not evident; and in which multiple sources of evidence are used.”

A case study was an appropriate fit to the present research of the alignment between the CAPS and the P1. An in-depth understanding of the case is the first primary obligation of the case study (Stake, 1995, p. 4) and is chosen based on the close examination of people, topics, issues or programs (Hays, 2004, p. 218). Accordingly, a case study research strategy was selected for this study as it encourages an examination of a contemporary situation by conducting a contextual investigation (Baxter & Jack, 2008, p. 548). Here, the contemporary situation is the use of current CAPS based curriculum since November 2014, and the contextual investigation refers to the content analysis of the CAPS document and the P1.

This study used a procedure that comprised the following six phases:

Phase one required a physics topic and cognitive demand classification of the content items of the CAPS Grade 12 Physics, Guidelines (2014 – 2017), and each question in the P1 (November 2014 – March 2018).

Phase two required that the classification data from Phase 1 be used to develop a CAPS Grade 12 Physics, four Guidelines (2014 – 2017) and eight P1 (November 2014 – March 2018) frequency matrices.

Phase three required that the data from the CAPS Grade 12 Physics frequency matrix be added to the each of the four Guidelines (2014 – 2017) frequency matrices to develop four CAPS (2014 – 2017) frequency matrices.

Phase four required a cell-by-cell division of the four CAPS frequency matrices (2014 – 2017) by the corresponding CAPS – Guidelines frequency matrix totals which resulted in the four CAPS (2014 – 2017) ratio matrices.

Phase five required a cell-by-cell absolute value difference of the eight P1 (November 2014 – March 2018) ratio matrices from corresponding cells of the four CAPS (2014 – 2017) ratio matrices which resulted in eight CAPS – P1 (November 2014 – March 2018) absolute differences matrices.

Phase six required that the absolute differences matrix total of each of the eight CAPS – P1 absolute differences matrices be used in Porter’s alignment equation to determine the AI between the CAPS and the P1.

3.4 RESEARCH APPROACH.

The objective of determining the alignment of the CAPS and the P1 was achieved using a case study research design. This study uses a quantitative and qualitative research approach for the content analysis of the CAPS and the P1. The quantitative approach used a list of explicit verbs (Table 11) to code the data. In cases where an explicit verb was not present, a qualitative approach was used to code the data. The results of the content analysis was applied to the SEC method to determine the four quantitative measures of alignment (Section 4.9).

3.5 SAMPLE SELECTION.

This study used a purposive sampling technique to select the documents included in the content analysis. The criteria for a sample selection is not based on randomness but rather on the subjective judgment of the researcher. The documents analysed in this study included:

- CAPS FET Phase Grades 10 – 12 Physical Sciences.
- Physical Sciences Examination Guidelines Grade 12 2014.
- Physical Sciences Examination Guidelines Grade 12 2015.
- Physical Sciences Examination Guidelines Grade 12 2016.
- Physical Sciences Examination Guidelines Grade 12 2017.
- NSC Grade 12 Physical Sciences: Physics (P1) November 2014.
- NSC Grade 12 Physical Sciences: Physics (P1) March 2015.
- NSC Grade 12 Physical Sciences: Physics (P1) November 2015.
- NSC Grade 12 Physical Sciences: Physics (P1) March 2016.
- NSC Grade 12 Physical Sciences: Physics (P1) November 2016.
- NSC Grade 12 Physical Sciences: Physics (P1) March 2016.
- NSC Grade 12 Physical Sciences: Physics (P1) November 2016.
- NSC Grade 12 Physical Sciences: Physics (P1) March 2017.
- NSC Grade 12 Physical Sciences: Physics (P1) November 2017.
- NSC Grade 12 Physical Sciences: Physics (P1) March 2018.

3.6 RESEARCH PROCESS.

Zhang and Wildemuth (2009, p. 3) described the following eight steps in the process of content analysis, preparing the data, defining the coding unit, developing a coding scheme, updating the coding scheme, coding the documents, assessing the coding consistency, using the coded data, and reporting the findings.

3.6.1 Preparing of the Data.

Microsoft Excel was used to import the CAPS and the P1. Subtopic; Content, concepts and skills; and CDL were the columns used for the CAPS coding (Section 3.7.1). Question, Mark, PST and CDL were the columns for the P1 question coding (Section 3.7.2).

3.6.2 Defining the Coding Unit.

Each question of the P1 was used as a coding unit. Question One of all the P1s analysed comprised of ten multiple choice questions (MCQ) encompassing all four topics of physics. The subsequent questions covered each topic individually. The coding unit used for the P1 was each of the four topics of physics (Section 2.7)

3.6.3 Developing a Coding Scheme.

The coding scheme used was based on the SEC alignment method (Porter, 2002). The coding concepts were used to classify the four levels of cognitive demand (Section 2.6) and the four topics of physics (Section 2.7) by using keywords. The keywords in the coding scheme were verbs of the cognitive demand levels. This study adopted the comprehensive list of verbs (Table 11) as described by Stanny (2016, p. 37) to ensure consistency in the coding scheme.

3.6.4 Updating the Coding Scheme.

MCQs provided four alternatives, of which, only one was correct. By using the verb, choose, all of the MCQs would have been coded CDL3 even though the cognitive processes involved in answering the MCQ was not application and analysis. MCQs were coded using a substantive coding process. The stem of certain MCQs (nested MCQs) included a list of statements about a specific topic.

Figure 6 shows Question 1.3 of the P1 March 2016 which is an example of a nested MCQ.

1.3	The statements below describe the motion of objects.	
	(i) A feather falls from a certain height inside a vacuum tube.	
	(ii) A box slides along a smooth horizontal surface at constant speed.	
	(iii) A steel ball falls through the air in the absence of air friction.	
	Which of the following describes UNIFORMLY ACCELERATED motion CORRECTLY?	
	A (i) and (ii) only	
	B (i) and (iii) only	
	C (ii) and (iii) only	
	D (i), (ii) and (iii)	(2)

Figure 6. P1 March 2016, Question 1.3. Extracted from "NSC Grade 12 Physical Sciences: Physics (P1) February/March 2016" (DBE, 2016b, p. 4). In the public domain.

The MCQ provided three statements about uniformly accelerated objects and four alternative answers, of which, only one was correct. The correct answer to the MCQ required analysing the stem list and applying the knowledge of the subject area. The cognitive processes involved was the application and analysis cognitive demand, therefore all nested MCQs were coded: CDL3.

Table 14 shows the verb assignments used when the P1 questions did not have an explicit verb.

Table 14

Verb Assignments

CDL1	Verb assigned
Yes or no Smaller than, equal to or greater than Which one of the following Towards or away Will it increase, decrease or remain the same	Select
Write down the Give examples of	List
What is the	Identify
CDL2	**Verb assigned**
What is meant by Give a reason for	Explain
CDL3	**Verb assigned**
Read off from the graph Use the graph to Refer to the graph and Using the graph	Interpret
Without any further calculation What conclusion can Deduce from the graph	Infer
Any reference to Gradient. Determine the value Show using a calculation Use equations to	Calculate

Note. CDL1, recall cognitive demand level. CDL2, comprehension cognitive demand level, CDL3, application and analysis cognitive demand level.

3.6.5 Coding the Documents.

This study used a combination of process coding and substantive coding. A list of keywords (Table 11) was the basis of process coding, and an understanding of the cognitive processes involved in the question was the basis for substantive.

Figure 7 shows Question 1.2 of the P1 November 2014 which did not have an explicit verb and therefore required substantive coding.

1.2 The magnitude of the gravitational force exerted by one body on another body is ***F***. When the distance between the centres of the two bodies is doubled, the magnitude of the gravitational force, in terms of ***F***, will now be …

A $\frac{1}{4}\boldsymbol{F}$

B $\frac{1}{2}\boldsymbol{F}$

C $2\boldsymbol{F}$

D $4\boldsymbol{F}$

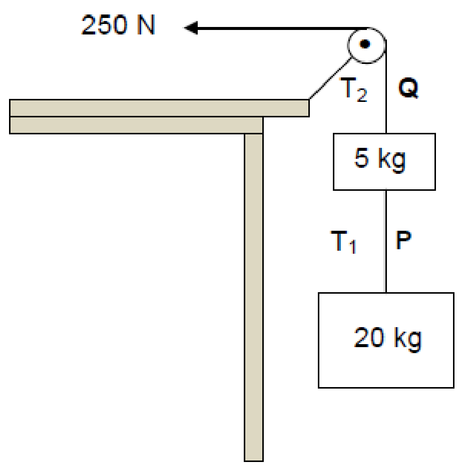
Figure 7. P1 November 2014, Question 1.2. Extracted from "NSC Grade 12 Physical Sciences: Physics (P1) November 2014" (DBE, 2014a, p. 3). In the public domain.

The topic of Question 1.2 is Newton's law of universal gravitation. An understanding that the force of gravitational attraction is inversely proportional to the squared distance between the bodies was required. The question also required an application of inverse proportionality and number squares. The cognitive process required by this question is application and was therefore coded: CDL3.

Figure 8 shows Question 2 of the P1 November 2014. The question was analysed first, to determine the physics topic and then the cognitive demand level. The entire question was part of the mechanics topic and was therefore coded: PST1. Each sub-question was further analysed to determine the cognitive processes involved.

QUESTION 2 (Start on a new page.)

Two blocks of masses 20 kg and 5 kg respectively are connected by a light inextensible string, **P**. A second light inextensible string, **Q**, attached to the 5 kg block, runs over a light frictionless pulley. A constant horizontal force of 250 N pulls the second string as shown in the diagram below. The magnitudes of the tensions in **P** and **Q** are T_1 and T_2 respectively. Ignore the effects of air friction.



2.1 State Newton's Second Law of Motion in words. (2)

2.2 Draw a labelled free-body diagram indicating ALL the forces acting on the **5 kg block**. (3)

2.3 Calculate the magnitude of the tension T_1 in string **P**. (6)

2.4 When the 250 N force is replaced by a sharp pull on the string, one of the two strings break.

Which ONE of the two strings, **P** or **Q**, will break? (1)

[12]

Figure 8. P1 November 2014, Question 2. Extracted from “NSC Grade 12 Physical Sciences: Physics (P1) November 2014” (DBE, 2014a, p. 8). In the public domain.

Question 2.1 required the exact wording of Newton’s second law of motion. An understanding of the application of the law was not required. The keyword identified in Question 2.1 was state which appears in the recall column of Table 11 and the question was therefore coded: CDL1.

Question 2.2 required an understanding of a free body diagram, applied force, gravitational force, and the force of tension. The free-body diagram required an understanding of these concepts. The keyword identified was draw which appears in the application and analysis column of Table 11. This question was therefore coded: CDL3

Question 2.3 required an understanding of a net force and how to apply the equation $F_{res} = ma$. The keyword identified in Question 2.3 was calculate which appears in the application and analysis column of Table 11. This question was therefore coded: CDL3.

Question 2.4 required an understanding of inertia and how to apply it to the situation proposed. The keyword identified in Question 2.3 was which and appears in the application and analysis column of Table 11. This question was therefore coded: CDL3.

3.6.6 Assessing the Coding Consistency.

Coding by humans is subjective and depends on the coder's interpretation, the result of this may be that different coders assign different codes same item. Coding consistency refers to the level of agreement between the coding choices of two or more coders (Hallgren, 2012, p. 23). This level of agreement also called the interrater coefficient measures the interrater reliability (Section 3.7.4).

Coding consistency in a study is crucial as it represents the extent to which the data collected appropriately represents the variables measured. The coding consistency affects the research questions and ultimately affects the findings of the study (McHugh, 2012, p. 276).

Dimick (2010, pp. 24-28) presented tips for ensuring coding consistency that included consistently training coders, auditing coding regularly, updating coding schemes regularly, discussing coding conflicts timeously, and promoting communication between coders.

This study used two raters; each rater coded the data on four separate occasions. The first three coding occasions where used a trial runs to familiarise the coders with the coding scheme and verb assignments in the substantive coding process. The data used in this study was the final coding attempt of the primary coder. The overall Cohen's kappa for the all the documents coded was 0.88 (Section 3.7.4). A list of verbs (Table 11) and verb assignments (Table 14) ensured the coding consistency.

3.6.7 Using the Coded Data.

The coded data was converted into a frequency matrix by a count of the number of times a cognitive demand code appeared within each physics topic (Section 4.3,Section 4.5 and Section 4.7). The frequency matrix was converted into a ratio matrix by dividing each cell value of the frequency matrix by the frequency matrix total. The ratio matrices were used to obtain absolute differences matrices by subtracting the P1 ratio matrix data from the CAPS ratio matrix data. The absolute difference matrix total was used in Porter's equation (Section 3.8.1) to determine the AI (Section 4.8).

3.6.8 Reporting the Findings.

Section 4.3 reported on the findings of the CAPS Grade 12 Physics coding. Section 4.5 reported on the findings of the Guidelines coding. Section 4.7 reported on the findings of the P1 coding. Section 4.9 reported on the findings of the alignment measures between the CAPS and the P1.

3.7 DATA COLLECTION INSTRUMENTS AND TOOLS.

This study used two data collecting instruments and a quantitative tool. The first instrument was used to classify the cognitive demand level of each question of the P1. The second instrument was used to classify the cognitive demand level of the content items in the CAPS Grade 12 Physics and the Guidelines documents. The quantitative tool, Porter's alignment equation was used to determine the AI between the CAPS and the P1.

3.7.1 CAPS Grade 12 Physics and the Guidelines Classification Instrument.

Table 15 shows the instrument used for the cognitive demand classification of the CAPS Grade 12 Physics and the Guidelines. The rubric has three columns: subtopic; content, concepts and skills; and CDL.

Table 15

CAPS Grade 12 Physics and Guidelines Classification Rubric

Subtopic	Content, concepts and skills	CDL

3.7.2 P1 Classification Instrument.

Table 16 shows the instrument used for the cognitive demand classification of each question of the P1. The rubric has four columns: Q, Marks, PST and CDL. Eight rubrics were used for the coding of the eight P1s from November 2014 to March 2018.

Table 16

P1 Classification Rubric

Q	Marks	PST	CDL

Note. Q, question number. Marks, mark allocated to each question of the P1.

3.7.3 Tool to Determine the Alignment between the CAPS and P1.

The tool used to calculate the AI between the CAPS and the P1 was Porter's alignment equation (Equation 2). The term $\sum_{i=1}^{n}|(X_i - Y_i)|$ in Porter's equation is equal to the sum total of the absolute differences matrix. There, the AI can be calculated as:

Equation 1

Alignment Index Calculation Tool

$$AI = 1 - \frac{\sum absolute\ differences\ matrix}{2}$$

3.7.4 Validity and Reliability.

Leung (2015, p. 328) described the validity of research as the suitability of the tools, processes, and data used in a study. This study used the tools and processes in the literature survey. Establishing validity in content analysis is a two-step process (Potter & Levine-Donnerstein, 1999, p. 266). The first step relies on a coding scheme that guides the coders in the analysis of the content. This study used a predefined coding scheme based on the SEC method. The second step assessed the decisions made by the coders against some standard. The standard used in this study was the keywords listed in Table 11.

Porter, Polikoff, Zeidner, and Smithson (2008, p. 32) stated that when using the SEC alignment method, the validity of the alignment index increases as the number of raters increases and further stated that the typical number of the raters ranges between 15 to 20 raters per alignment study. However, studies analysed by Coleman (2017, p. 32) indicated that the number of raters might be as low as two. When the classification involved multiple subjects across multiple grades, a higher number of raters are involved. In the SEC alignment method, raters are only required to analyse the examinations and use the pre-analysed SEC curriculum frequency matrix to determine the alignment. Two raters performed the coding in this study, which included one subject (Physical Sciences) and one grade (Grade 12).

The reliability of the SEC alignment method and Porter's alignment index was affected by rater effects. The rater effects included the number of raters, the rater's experiences and expertise, the rater's knowledge of the education system and the rater's knowledge of the target population. The use of an interrater reliability coefficient quantified the consistency and the dependability of the SEC alignment method and Porter's equation. The literature review identified several methods that were used to compute the interrater reliability coefficient. These methods included: the correlation coefficient (r); Krippendorff's alpha (a); Cohen's kappa (k); Fleiss kappa (k); and the interclass correlation coefficient (ICC) (Coleman, 2017, p. 32). This study used the Cohen's kappa method, often only referred to as kappa, to calculate the interrater reliability coefficient.

Coleman (2017, p. 31) interpreted kappa values greater than 0.61 to 0.80 as substantial and kappa values of 0.81 to 1.00 as almost perfect. Porter *et al.* (2008, p. 47) reported on the work of Porter (2002) who computed an interrater reliability coefficient of 0.7 for two raters and an interrater reliability coefficient to 0.80 for four raters. Porter *et al.* (2008, p. 47) also reported that increasing the number of raters beyond four, reduced the interrater reliability coefficient. Table 17 shows the calculated kappa values for each document analysed (Appendix HH). The overall interrater reliability coefficient for all the documents coded in this study is 0.88 which is higher than the 0.70 of Porter (2002) and was described as almost perfect reliability by Coleman (2017, p. 31).

Table 17

Cohen's Kappa Interrater Reliability Coefficient

Document rated	Kappa	Interpretation
CAPS Grade 12 Physics	0.91	Almost perfect
Guidelines 2014	0.98	Almost perfect
Guidelines 2015	0.99	Almost perfect
Guidelines 2016	0.96	Almost perfect
Guidelines 2017	0.95	Almost perfect
Guidelines (2014 – 2017)	0.97	Almost perfect
P1 November 2014	0.83	Almost perfect
P1 March 2015	0.89	Almost perfect
P1 November 2015	0.70	Substantial
P1 March 2016	0.61	Substantial
P1 November 2016	0.68	Substantial
P1 March 2017	0.67	Substantial
P1 November 2017	0.78	Substantial
P1 March 2018	0.75	Substantial
P1 (November 2014 – March 2018)	0.74	Substantial
Overall	0.88	Almost perfect

3.8 METHODOLOGY.

The documents analysed in this study were the CAPS Grade 12 Physics document, the Guidelines (2014 – 2017) and the final and supplementary P1 examinations for the period November 2014 to March 2018. All documents analysed in this study were electronic except for except the P1 November 2017 and the P1 March 2018 documents which were obtained as hard copies. The documents are available for download from the Department of Basic Education's website (www.dbe.gov.za) and the South African Comprehensive Assessment Institute's website (www.sacai.org.za).

Hsieh and Shannon (2005, p. 1283) described the summative content analysis. The analysis included the concepts of the four physics topics as defined by the DBE (2017c, p. 5) as well as the modified Bloom's taxonomy as included in the DBE (2017c, p. 5). This study investigated the validity and reliability of the coding process as described by Coleman (2017, p. 238) and Potter *et al.* (1999, p. 266).

The SEC alignment method which was developed by the Department of Education Oregon (1998) included the concepts of frequency, ratio, and absolute differences matrices. Ndlovu and Mji (2012, p. 4) illustrated these matrix concepts by using a pair of two by two matrices. They further quantified results of the content analysis by the use of Porter's alignment equation.

The quantitative alignment index (AI) was developed by Porter *et al.* (2001). G. W. Fulmer (2010, p. 8) provided an interpretation of the AI and its strength as an alignment measure. Trends and comparisons of the AI were identified in the studies conducted by G. Fulmer *et al.* (2009, p. 787), Edwards (2010, p. 586) and Guo *et al.* (2012, p. 38).

3.8.1 Porter's Alignment Equation.

The AI between the curriculum and the examination was calculated using Porter's alignment equation. The AI ranges between zero to one with an AI of zero indicating no alignment and an AI of one indicating perfect alignment (Liang & Yuan, 2008, p. 1829).

The AI calculation requires two, dimensionally equal matrices (Matrix X and Matrix Y). One matrix represents the proportional data of the curriculum, and the other matrix represents the proportional data of the examination. The term $\sum_{i=1}^{n}|(X_i - Y_i)|$ in Porter's equation, represents the cell by cell non-intersects between the two matrices: the total difference of proportional data between the curriculum and the examination (Porter, 2002, p. 5).

Equation 2

Porter's Alignment Equation

$$AI = 1 - \frac{\sum_{i=1}^{n}|(X_i - Y_i)|}{2}$$

Equation 2 shows Porter's equation in which:

n refers to the total number of entries in each matrix;

i refers to an integer from 1 to n;

X_i refers to the i^{th} cell of Matrix X;

Y_i refers to the i^{th} cell of Matrix Y;

$|(X_i - Y_i)|$ refers to the absolute difference between corresponding cells in each matrix;

$\sum_{i=1}^{n}|(X_i - Y_i)|$ refers to the sum of all the absolute differences matrix.

There are no established criteria to determine the strength of the AI as a measure of alignment (G. W. Fulmer, 2010, p. 383) since the calculation of the AI is dependent on the number of categories and the number of content items classified (G. W. Fulmer, 2010, p. 386). Due to the lack of studies covering all possible ranges of table sizes and the number of content items classified, G. W. Fulmer (2010) developed a computational algorithm to simulate critical AI values. The algorithm simulated table sizes of 30, 60, 90 and 120 and content items from 10 to 114. The results of the computational was a list of critical AI values in the alpha levels of 0.1 and 0.05 for a one and two-tailed tests (G. W. Fulmer, 2010, p. 383). A comparison of the calculated AI to the to the critical AI determined its relative strength. The calculated AI is only statistically significant if it is higher than the critical AI value.

3.8.2 Surveys of the Enacted Curriculum (SEC) Method.

The SEC method was demonstrated using simplified versions of a curriculum, guidelines and examination as an example. The SEC method comprises six phases.

Phase 1.

A summative content analysis was conducted to classify the content items of the curriculum, guidelines, and each question of the examination according to two topics and two cognitive level. Figure 9 shows the results of the classification.

CURRICULUM		
ITEM	TOPIC	LEVEL
1	1	2
2	1	1
3	1	1
4	1	1
5	1	2
6	1	2
7	2	2
8	2	1
9	2	1
10	2	2

GUIDELINES		
ITEM	TOPIC	LEVEL
1	1	2
2	1	1
3	1	1
4	1	1
5	2	1
6	2	2
7	2	2
8	2	1
9	2	1
10	2	2

EXAMINATION		
QUEST.	TOPIC	CODE
1	1	2
2	1	1
3	1	2
4	1	2
5	1	2
6	1	2
7	1	1
8	2	1
9	2	1
10	2	2

Figure 9. Curriculum, Guidelines, and Examination Classification

Phase 2.

The data of phase one was used to develop a "two by two" dimension frequency matrix for the curriculum (C), guidelines (G) and the examination (E). Figure 10 shows the curriculum frequency matrix, guidelines frequency matrix, and examination frequency matrix.

FREQUENCY MATRIX		
C	Level 1	Level 2
Topic 1	3	2
Topic 2	3	2
MATRIX SUM		10

FREQUENCY MATRIX		
G	Level 1	Level 2
Topic 1	3	1
Topic 2	3	3
MATRIX SUM		10

FREQUENCY MATRIX		
E	Level 1	Level 2
Topic 1	2	5
Topic 2	2	1
MATRIX SUM		10

Figure 10. Curriculum, Guidelines, and Examination Frequency Matrices

Phase 3.

The curriculum frequency matrix was added to the guidelines frequency matrix to form the curriculum guidelines frequency matrix. Figure 11 shows the curriculum guidelines frequency matrix.

FREQUENCY MATRIX

C + G	Level 1	Level 2
Topic 1	6	3
Topic 2	6	5
	MATRIX SUM	20

Figure 11. Curriculum and Guidelines Frequency MatrixPhase 4.

Each cell value in the curriculum guidelines frequency matrix was divided by the curriculum guidelines frequency matrix total and entered into the corresponding cell of the curriculum guidelines ratio matrix. Each cell value in the examination frequency matrix was then divided by the examination frequency matrix total and entered into the corresponding cell of the examination ratio matrix. Figure 12 shows the curriculum, guidelines ratio matrix and the examination ratio matrices.

RATIO MATRIX

C + G	Level 1	Level 2
Topic 1	0.3	0.15
Topic 2	0.3	0.25
	MATRIX SUM	1

RATIO MATRIX

E	Level 1	Level 2
Topic 1	0.2	0.5
Topic 2	0.2	0.1
	MATRIX SUM	1

Figure 12. Curriculum, Guidelines, and Examination Ratio Matrix

Phase 5.

A cell-by-cell absolute value difference of the E ratio matrix from corresponding cells of the C + G ratio matrix resulted in the absolute differences matrices. The total of the absolute differences matrix represented the term $\sum_{i=1}^{n}|(X_i - Y_i)|$ in Porter's equation. Figure 13 shows the absolute differences matrix.

ABSOLUTE DIFFERENCES MATRIX

	0.1	0.35
	0.1	0.15
MATRIX SUM		0.7

Figure 13. Absolute Differences Matrix.Phase 6.

Substituting the absolute differences matrix total for the term $\sum_{i=1}^{n}|(X_i - Y_i)|$ in Porter's equation yielded the AI as follows:

$$AI = 1 - \frac{\sum_{i=1}^{n}|(X_i - Y_i)|}{2}$$

$$AI = 1 - \frac{0.7}{2}$$

$$AI = 0.65$$

The AI for the simplified curriculum, guidelines and the examination was 0.65.

illustrates the methodology used in this study.

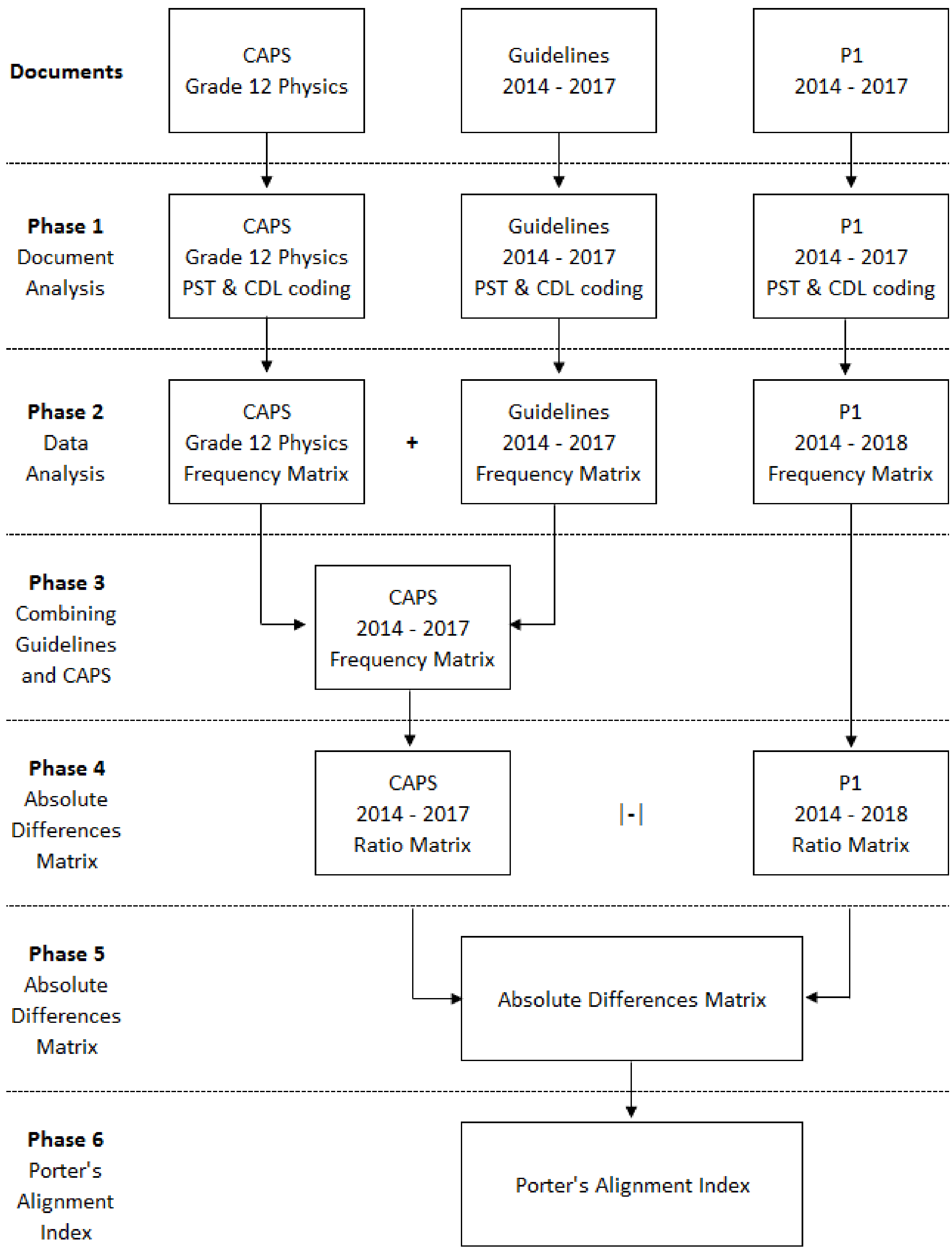


Figure 14. The Methodology.

3.9 SUMMARY OF CHAPTER THREE.

Table 18 shows a summary of the research design used in this study.

Table 18

Summary of Research Design and Methodology

Research Item	Description
Domain	Physics education
Purpose	To determine the alignment between the CAPS and the P1.
Research paradigm	Positivist
Research methodology	Quantitative and qualitative
Strategy	Case study
Sampling	Purposive
Analytic technique	Summative content analysis
Timeframe	Cross-sectional
Coding scheme	SEC method and a list of verbs
Research tool	Porter's alignment index

This chapter described the research paradigm, ontology, epistemology, axiology, research methodology, research strategy, sampling, analytic technique, time frame, coding scheme, research tool and the research instruments used in this study. This chapter also discussed the validity and reliability of the instruments used, reported on the methods of coding the data, and the procedure of computing an alignment index. The next chapter discusses the analysis of the documents and the research questions.

CHAPTER 4

DATA ANALYSIS AND FINDINGS

4.1 INTRODUCTION.

This chapter presented the analysis and findings for the coding classification of the CAPS Grade 12 Physics, Guidelines (2014 - 2018) and P1 (November 2014 - March 2018). Section 4.2 demonstrates the coding of the CAPS using the waves, sound and light topic. The coding of the CAPS for all topics is included in Appendix C. Section 4.3 presents findings for the classification of CAPS Grade 12 Physics.

Section 4.4 demonstrates the coding of the optical phenomena topic of the Guidelines 2014. The coding of the Guidelines (2014 – 2017) for all topics is presented in Appendix D to Appendix G. Section 4.5 presents the findings for the classification of the Guidelines 2014. The findings of the Guidelines 2015, Guidelines 2016 and Guidelines 2017 are presented in Appendix P, Appendix Q and Appendix R respectively.

Section 4.5 demonstrates the coding process of the P1 November 2014. The coding of the P1 (March 2015 – March 2018) is presented in Appendix H to Appendix O. Section 4.7 presents findings for the classification of the P1 November 2014. The findings of the P1 March 2015 to P1 March 2018 is presented in Appendix S to Appendix Y.

Section 4.9 presents a restatement of the research questions. Sections 4.9.1 to Section 4.9.4 presents answers to the research questions and Section 4.10 shows a summary of the results of the research questions.

4.2 ANALYSIS OF THE CAPS GRADE 12 PHYSICS.

The analysis of the content items of the CAPS Grade 12 Physics required a classification according to the four physics topics and the four cognitive demand levels. Table 19 shows the classification of the waves, sound and light topic. The classification of the mechanics; electricity and magnetism; and optical phenomena topics was also conducted (Appendix C).

Figure 15 shows an extract of the CAPS Grade 12 Physics for the waves, sound and light content (DBE, 2011b, pp. 121-122). A comparison of the verbs in the "Content, Concepts and Skills" column of Figure 15 to the list of verbs in Table 11 determined the cognitive demand level of each content item.

Time	Topics Grade 12	Content, Concepts & Skills
6 HOURS	**Doppler Effect (relative motion between source observer)**	
4 hours	With sound and ultrasound	• State the Doppler Effect for sound and give everyday examples. • Explain (using appropriate illustrations) why a sound increases in pitch when the source of the sound travels towards a listener and decreases in pitch when it travels away • Use the equation $f_L = \frac{v \pm v_L}{v \pm v_S} f_S$ to calculate the frequency of sound detected by a listener (L) when **EITHER** the source or the listener is moving • Describe applications of the Doppler Effect with ultrasound waves in medicine, e.g. to measure the rate of blood flow or the heartbeat of a foetus in the womb
2 hours	With light - red shifts in the universe (evidence for the expanding universe).	• State that light emitted from many stars is shifted toward the red, or longer wavelength/lower frequency, end of the spectrum due to movement of the source of light • Apply the Doppler Effect to these "red shifts" to conclude that most stars are moving away from Earth and therefore the universe is expanding

Figure 15. Extract of the CAPS Grade 12 Physics. Extracted from "NSC CAPS FET Phase Grade 12 Physical Sciences" (DBE, 2011b, pp. 121-122). In the public domain.

Each content item in the waves, sound and light topic of the CAPS Grade 12 Physics was numbered 1 to 6 in Table 19. The verb identified in item No. 1 is State and corresponds to CDL1 in Table 11, the verb identified in item No. 2 is Explain and corresponds to CDL2 in Table 11, the verb identified in item No. 3 is Calculate and corresponds to CDL3 in Table 11, the verb identified in item No. 4 is Describe and corresponds to CDL2 in Table 11, the verb identified in item No. 5 is State and corresponds to CDL1 in Table 11, and the verb identified in item No. 6 is Apply and corresponds to CDL3 in Table 11.

Table 19

Cognitive Demand Level of the CAPS Grade 12 Physics

Subtopic	No.	Content	Verb	CDL
Sound and Ultrasound	1	State the Doppler Effect for sound and give everyday examples.	State	1
	2	Explain (using appropriate illustrations) why a sound increases in pitch when the source of the sound travels towards a listener and decreases in pitch when it travels away.	Explain	2
	3	Use the equation $f_l = \left(\frac{v \pm v_l}{v \pm v_s}\right) f_s$ to calculate the frequency of sound detected by a listener (L) when EITHER the source or the listener is moving.	Calculate	3
	4	Describe applications of the Doppler Effect with ultrasound waves in medicine, e.g. to measure the rate of blood flow or the heartbeat of a foetus in the womb.	Describe	2
Redshifts in the universe	5	State that light emitted from many stars is shifted toward the red, or longer wavelength/lower frequency, end of the spectrum due to movement of the source of light.	State	1
	6	Apply the Doppler Effect to these "redshifts" to conclude that most stars are moving away from Earth and therefore the universe is expanding.	Apply	3

4.3 FINDINGS OF THE CAPS GRADE 12 PHYSICS ANALYSIS.

Table 20 shows the teaching time allocation to each subtopic in the CAPS Grade 12 Physics.

Table 20

Time Allocation and Subtopics in the CAPS Grade 12 Physics

Physics topic	Subtopics	Percent	Time allocated	Percent
Mechanics	14	48.3	28 hours	53.8
Waves, sound and light	3	10.3	6 hours	11.5
Electricity and magnetism	10	34.5	12 hours	23.1
Optical phenomena	2	6.9	6 hours	11.5
Total	29	100.0	52 hours	100.0

Note. From "Curriculum and Assessment Policy Statement Grades 10 - 12 Physical Sciences" (DBE, 2011b, p. 129). In the public domain.

Table 21 shows the physics topic weighting, Table 22 shows the cognitive demand, Table 23 shows the frequency matrix, and Figure 16 shows the cognitive demand distribution of the CAPS Grade 12 Physics. There are 149 content items in the CAPS Grade 12 Physics. The mechanics topic comprises 84 content items; the waves, sound and light topic comprises six items; the electricity and magnetism topic comprises 47 content items, and the optical phenomena topic comprises 12 content items.

Table 21

CAPS Grade 12 Physics Topic Weighting

Physics topic	PST Code	Frequency	Percent
Mechanics	1	84	56.4
Waves, sound and light	2	6	4.0
Electricity and magnetism	3	47	31.5
Optical phenomena	4	12	8.1
Total		149	100.0

Table 21 also shows that the mechanics topic is the most used while the waves, sound and light topic is the least used topic in the CAPS Grade 12 Physics. The physics topic distribution of the CAPS Grade 12 Physics in decreasing order of frequency is mechanics (54.6 percent); electricity and magnetism (31.5 percent); optical phenomena (8.1 percent) and waves, sound and light (4.0 percent).

Table 22 shows that the recall cognitive demand comprises 57 content items, the comprehension cognitive demand comprises 30 content items, and the application and analysis cognitive demand comprises 62 content items. Table 22 also shows that the most utilised cognitive demand is the application and analysis cognitive demand, closely followed by the recall cognitive demand. Synthesis and evaluation, the highest cognitive demand level is not utilised in the CAPS Grade 12 Physics. The cognitive demand distribution of the CAPS Grade 12 Physics in decreasing order of frequency is application and analysis (41.6 percent); recall (38.3 percent); comprehension (20.1); and synthesis and evaluation (zero percent).

Table 22

CAPS Grade 12 Physics Cognitive Demand Level Weighting

Cognitive demand level	CDL Code	Frequency	Percent
Recall	1	57	38.3
Comprehension	2	30	20.1
Application and analysis	3	62	41.6
Synthesis and evaluation	4	0	0.0
Total		149	100.0

Table 23 is the CAPS Grade 12 Physics frequency matrix which was obtained by a count of each cognitive demand level within each physics topic. The CAPS Grade 12 Physics frequency matrix was used to develop the CAPS ratio matrix (Section 4.3).

Table 23

CAPS Grade 12 Physics Frequency Matrix

Physics topic	Cognitive demand level (number of items)				Total
	CDL1	CDL2	CDL3	CDL4	
PST1	34	14	36	0	84
PST2	2	2	2	0	6
PST3	16	8	23	0	47
PST4	5	6	1	0	12
Total	57	30	62	0	149

Note. PST1, mechanics. PST2, waves, sound and light. PST3, electricity and magnetism. PST4, optical phenomena.

Table 23 shows the cognitive demand distribution of the CAPS Grade 12 Physics. The physics topic distribution favours the mechanics topic and the application and analysis cognitive demand. Within the mechanics topic, the application and analysis cognitive demand is the most prominent followed by the recall and comprehension cognitive demands. The CAPS Grade 12 Physics does not use the highest cognitive demand level, synthesis and evaluation. The electricity and magnetism topic has a cognitive demand distribution similar to the mechanics topic. The mechanics topic contains the highest frequency of all cognitive demand levels. Figure 16 shows that the CAPS Grade 12 Physics is weighted in favour of the application and analysis cognitive demand within the mechanics topic.

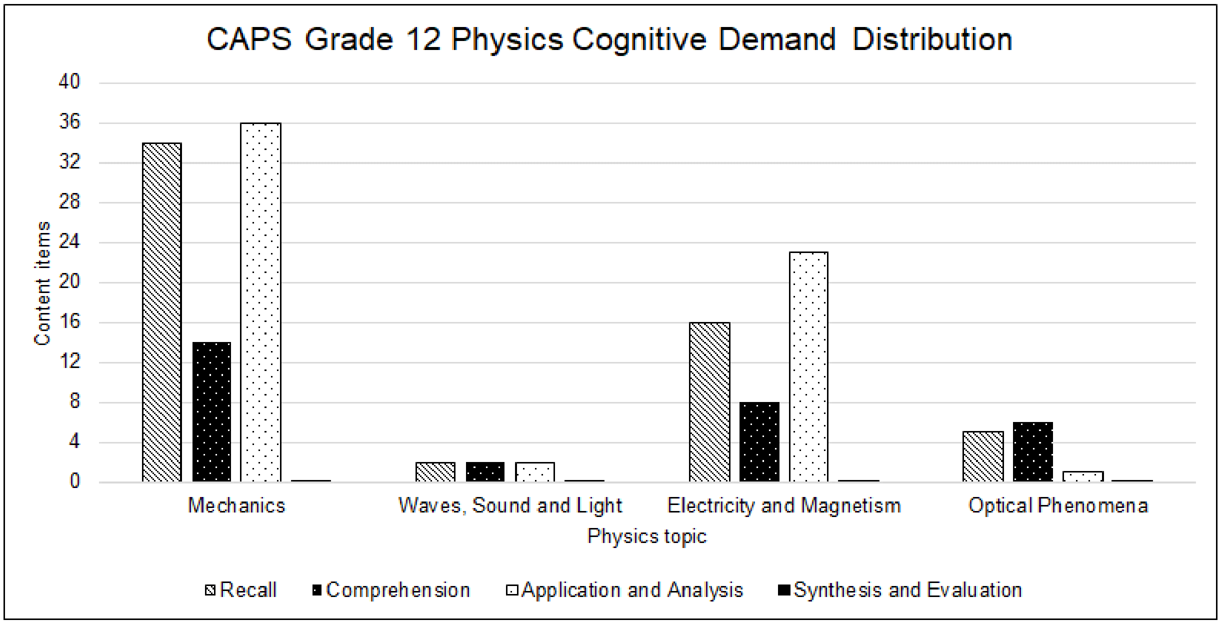


Figure 16. CAPS Grade 12 Physics Cognitive Demand Distribution.

4.4 ANALYSIS OF THE GUIDELINES 2014.

The content items of the Guidelines 2014 required a classification according to the four topics of physics and the four levels of cognitive demand. Table 19 shows the classification for the optical phenomena topic from the Guidelines 2014. The classification of the mechanics; waves, sound and light; and electricity and magnetism topics was also conducted (Appendix D to Appendix G). Figure 17 shows an extract of the optical phenomena topic from the Guidelines 2014 (DBE, 2014b, p. 13). The cognitive demand level of the verb was assessed using The verb identified in item No. 1 is Describe and corresponds to CDL2 in Table 11. The verb identified in item No. 2 is State and corresponds to CDL1 in Table 11, the verb identified in item No. 3 is Define and corresponds to CDL1 in Table 11, the verb identified in item No. 4 is Define and corresponds to CDL1 in Table 11, the verb identified in item No. 5 is Calculate and corresponds to CDL3 in Table 11, the verb identified in item No. 6 is Explain and corresponds to CDL2 in Table 11, the verb identified in item No. 7 is Explain and corresponds to CDL2 in Table 11, and the verb identified in item No. 8 is Explain and corresponds to CDL2 in Table 11.

Photo-electric effect

- Describe the *photoelectric effect* as the process whereby electrons are ejected from a metal surface when light of suitable frequency is incident on that surface.
- State the significance of the photoelectric effect.
- Define *threshold frequency*, f_o, as the minimum frequency of light needed to emit electrons from a certain metal surface.
- Define *work function*, W_o, as the minimum energy that an electron in the metal needs to be emitted from the metal surface.
- Perform calculations using the photoelectric equation:
  $E = W_o + K_{max}$, where $E = hf$ and $W_o = hf_o$ and $K_{max} = ½mv^2_{max}$
- Explain the effect of intensity and frequency on the photoelectric effect.

Emission and absorption spectra

- Explain the *formation of atomic spectra* by referring to energy transition.
- Explain the difference between *atomic absorption spectra* and *atomic emission spectra*.
  An atomic absorption spectrum is formed when certain frequencies of electromagnetic radiation that passes through a medium, e.g. a cold gas, is absorbed.
  An atomic emission spectrum is formed when certain frequencies of electromagnetic radiation are emitted due to an atom's electrons making a transition from a high-energy state to a lower energy state.

Figure 17. Extract of the Guidelines 2014 Optical Phenomena Topic. Extracted from "Physical Sciences Examination Guidelines Grade 12" (DBE, 2014b, p. 13). In the public domain.

Table 24

Guidelines 2014 Cognitive Demand Classification

Subtopic	No.	Content	Verb	CDL
Photo-electric Effect	1	Describe the photoelectric effect as the process whereby electrons are ejected from a metal surface when light of suitable frequency is incident on that surface.	Describe	2
	2	State the significance of the photoelectric effect.	State	1
	3	Define threshold frequency, f_o, as the minimum frequency of light needed to emit electrons from a certain metal surface.	Define	1
	4	Define work function, Wo, as the minimum energy that an electron in the metal needs to be emitted from the metal surface.	Define	1
	5	Perform calculations using the photoelectric equation: $E = W_o + K_{max}$, where $E = hf$ and $W_o = hf_o$ and $K_{max} = ½mv^2_{max}$	Calculate	2
	6	Explain the effect of intensity and frequency on the photoelectric effect.	Explain	2
Emission and Absorption Spectra	7	Explain the formation of atomic spectra by referring to energy transition.	Explain	2
	8	Explain the difference between atomic absorption spectra and atomic emission spectra.	Explain	2

4.5 FINDINGS OF THE GUIDELINES 2014 ANALYSIS.

This section presents the findings of the Guidelines 2014 analysis. The findings of the analysis of the Guidelines 2015, Guidelines 2016 and Guidelines 2017 are presented in Appendix. The physics topic and cognitive demand classification of the Guidelines 2014 is presented using the Guidelines 2014 physics topic weighting (Table 25), the Guidelines 2014 cognitive demand level weighting (Table 26), the Guidelines 2014 cognitive demand distribution (Figure 18), the Guidelines 2014 frequency matrix (Table 27), the CAPS 2014 frequency matrix (Table 28), and the CAPS 2014 ratio matrix (Table 29).

Table 25 shows that there are 133 content items in the Guidelines 2014. The mechanics topic includes 81 content items, the waves, sound and light topic includes six content items, the electricity and magnetism topic includes 37 content items; and the optical phenomena topic includes nine content items. Table 25 also shows that the Guidelines 2016 most frequently used the mechanics topic and least frequently used the waves, sound and light topic. The physics topic distribution of the Guidelines 2014 in decreasing order of frequency is mechanics (60.9 percent); electricity and magnetism (27.8 percent); optical phenomena (6.8 percent); and waves, sound and light (4.5 percent).

Table 25

Guidelines 2014 Physics Topic Weighting

Physics topic	PST code	Frequency	Percent
Mechanics	1	81	60.9
Waves, sound and light	2	6	4.5
Electricity and magnetism	3	37	27.8
Optical phenomena	4	9	6.8
Total		133	100.0

Table 26 shows that the recall cognitive demand includes 39 content items, the comprehension cognitive demand includes 36 content items, and the application and analysis cognitive demand includes 58 content items. The cognitive demand distribution of the Guidelines 2014 in decreasing order of frequency is application and analysis (43.6 percent); recall (29.3 percent); comprehension (27.1 percent); and synthesis and evaluation (zero percent).

Table 26 also shows that the most utilised cognitive demand is the application and analysis cognitive demand, closely followed by the recall cognitive demand. Synthesis and evaluation, the highest cognitive demand level is not utilised in the Guidelines 2014. The cognitive demand distribution of the Guidelines 2014 in decreasing order of frequency is application and analysis (43.6 percent); recall (29.3 percent); comprehension (27.1 percent); and synthesis and evaluation (zero percent).

Table 26

Guidelines 2014 Cognitive Demand Level Weighting

Cognitive demand level	CDL code	Frequency	Percent
Recall	1	39	29.3
Comprehension	2	36	27.1
Application and analysis	3	58	43.6
Synthesis and evaluation	4	0	0.0
Total		133	100.0

Figure 18 shows the cognitive demand distribution of the Guidelines 2014 which favours the mechanics topic and the application and analysis cognitive demand. The mechanics and the electricity and magnetism topics have similar cognitive demand distributions with the application and analysis cognitive demand having the highest frequency followed by the recall cognitive demand and then comprehension cognitive demand. The waves, sound and light topic and the optical phenomena topic have similar cognitive demand distributions with the comprehension cognitive demand having the highest frequency followed by the recall cognitive demand. The Guidelines 2014 did not have the synthesis and evaluation cognitive demand.

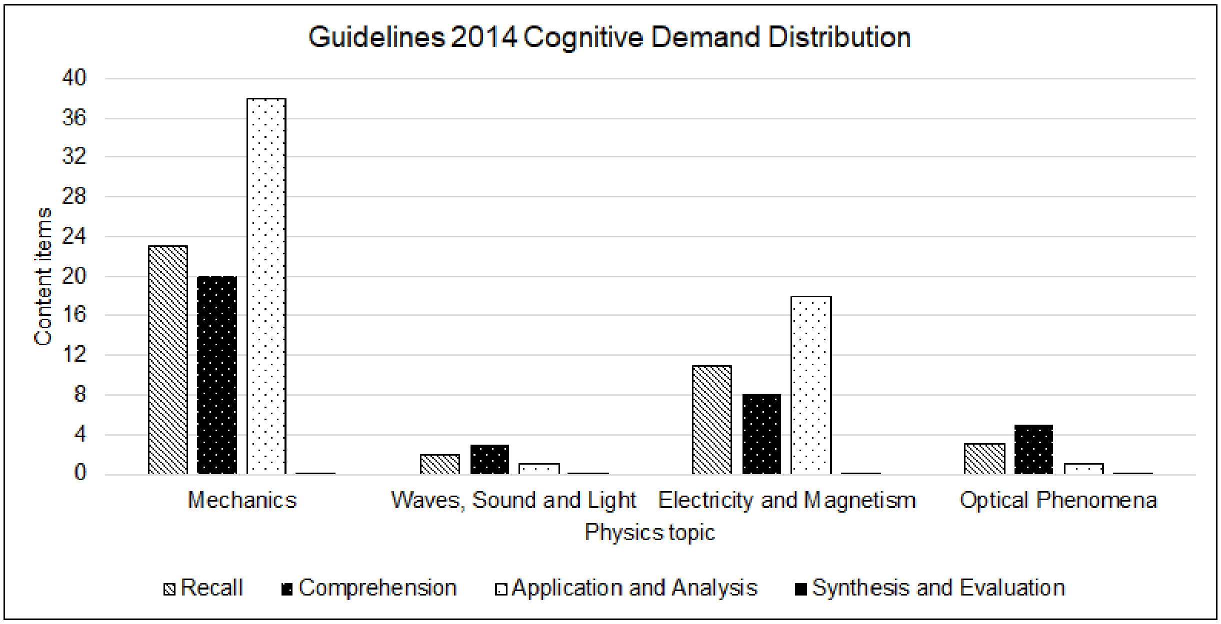


Figure 18. Guidelines 2014 Cognitive Demand Distribution. A tally of each cognitive demand level within each physics topic produced the Guidelines 2014 frequency matrix. Table 27 shows the Guidelines 2014 frequency matrix.

Table 27

Guidelines 2014 Frequency Matrix

Physics topic	Cognitive demand level (number of items)				Subtotal
	CDL1	CDL2	CDL3	CDL4	
PST1	23	20	38	0	81
PST2	2	3	1	0	6
PST3	11	8	18	0	37
PST4	3	5	1	0	9
Total	39	36	58	0	133

Note. CDL1, recall. CDL2, comprehension. CDL3, application and analysis. CDL4, synthesis and evaluation.

The cell-by-cell addition of the CAPS Grade 12 Physics (Table 23) and the Guidelines 2014 frequency matrices (Table 27) produced the CAPS 2014 frequency matrix shown in Table 28.

Table 28

CAPS 2014 Frequency Matrix

Physics topic	Cognitive demand level (number of items)				Total
	CDL1	CDL2	CDL3	CDL4	
PST1	57	34	74	0	165
PST2	4	5	3	0	12
PST3	27	16	41	0	84
PST4	8	11	2	0	21
Total	96	66	120	0	282

A cell-by-cell division of the CAPS 2014 frequency matrix (Table 28) by the CAPS 2014 frequency matrix total (282) resulted in the CAPS 2014 ratio matrix. Table 29 shows the CAPS 2014 ratio matrix.

Table 29

CAPS 2014 Ratio Matrix

Physics topic	Cognitive demand level (number of items divided by 282)			
	CDL1	CDL2	CDL3	CDL4
PST1	0.2021	0.1206	0.2624	0.000
PST2	0.0142	0.0177	0.0106	0.000
PST3	0.0957	0.0567	0.1454	0.000
PST4	0.0284	0.0390	0.0071	0.000

4.6 ANALYSIS OF P1 NOVEMBER 2014.

This section used the P1 November 2014 to demonstrate the Physics topic and cognitive demand classification of the P1.

4.6.1 Question One Coding Classification.

Question One of the P1 November 2014 comprises ten two-mark MCQs based on all four physics topics. Table 30 shows the coding classification of the P1 November 2014, Question One.

Table 30

P1 November 2014 Question One Coding Classification

Question	Physics topic	PST code	Cognitive demand level	CDL code
1.1	Mechanics	1	Recall	1
1.2	Mechanics	1	Application and analysis	3
1.3	Mechanics	1	Recall	1
1.4	Mechanics	1	Comprehension	2
1.5	Mechanics	1	Application and analysis	3
1.6	Waves, sound and light	2	Application and analysis	3
1.7	Electricity and magnetism	3	Comprehension	2
1.8	Electricity and magnetism	3	Comprehension	2
1.9	Electricity and magnetism	3	Application and analysis	3
1.10	Optical phenomena	4	Application and analysis	3

4.6.2 Question Two Coding Classification.

Question Two of the P1 November 2014 comprises four sub-questions all based on the mechanics topic and was accordingly coded PST1. Table 31 shows the coding classification of the P1 November 2014, Question Two.

Table 31

P1 November 2014 Question Two Coding Classification

Question	Mark	Verb	Cognitive demand level	CDL code
2.1	2	State	Recall	1
2.2	3	Draw	Application and analysis	3
2.3	6	Calculate	Application and analysis	3
2.4	1	Which one	Recall	1

4.6.3 Question Three Coding Classification.

Question Three of the P1 November 2014 comprises four sub-questions all based on the mechanics topic and was accordingly coded PST1. Table 32 shows the coding classification of the P1 November 2014, Question Three.

Table 32

P1 November 2014 Question Three Coding Classification

Question	Mark	Verb	Cognitive demand level	CDL code
3.1	2	Explain	Comprehension	2
3.2	4	Calculate	Application and analysis	3
3.3	7	Calculate	Application and analysis	3
3.4	4	Sketch	Application and analysis	3

4.6.4 Question Four Coding Classification.

Question Four of the P1 November 2014 comprises five sub-questions all based on the mechanics topic and was accordingly coded PST1. Table 33 shows the coding classification of the P1 November 2014, Question Four.

Table 33

P1 November 2014 Question Four Coding Classification

Question	Mark	Verb	Cognitive demand level	CDL code
4.1	3	Calculate	Application and analysis	3
4.2	2	Define	Recall	1
4.3	3	Calculate	Application and analysis	3
4.4	1	Select	Recall	1
4.5	3	Explain	Comprehension	2

4.6.5 Question Five Coding Classification.

Question Five of the P1 November 2014 comprises five sub-questions all based on the mechanics topic and was accordingly coded PST1. Table 34 shows the coding classification of the P1 November 2014, Question Five.

Table 34

P1 November 2014 Question Five Coding Classification

Question	Mark	Verb	Cognitive demand level	CDL code
5.1.1	2	State	Recall	1
5.1.2	1	Select	Recall	1
5.1.3	6	Calculate	Application and analysis	3
5.2.1	3	Calculate	Application and analysis	3
5.2.2	6	Calculate	Application and analysis	3

4.6.6 Question Six Coding Classification.

Question Six of the P1 November 2014 comprises four sub-questions all based on the waves, sound and light topic and was accordingly coded PST2. Table 35 shows the coding classification of the P1 November 2014, Question Six.

Table 35

P1 November 2014 Question Six Coding Classification

Question	Mark	Verb	Cognitive demand level	CDL code
6.1.1	2	State	Recall	1
6.1.2	2	Explain	Comprehension	2
6.1.3	5	Calculate	Application and analysis	3
6.2	2	Explain	Comprehension	2

4.6.7 Question Seven Coding Classification.

Question Seven of P1 November 2014 comprises seven sub-questions all based on the electricity and magnetism topic and was accordingly coded PST3. Table 36 shows the coding classification of the P1 November 2014, Question Seven.

Table 36

P1 November 2014 Question Seven Coding Classification

Question	Mark	Verb	Cognitive Demand Level	CDL code
7.1	1	Explain	Comprehension	2
7.2	2	Calculate	Application and analysis	3
7.3	3	Draw	Application and analysis	3
7.4	2	Draw	Application and analysis	3
7.5	6	Calculate	Application and analysis	3
7.6	2	Define	Recall	1
7.7	3	Calculate	Application and analysis	3

4.6.8 Question Eight Coding Classification.

Question Eight of the P1 November 2014 comprises nine sub-questions all based on the electricity and magnetism topic and was accordingly coded PST3. Table 37 shows the coding classification of the P1 November 2014, Question Eight.

Table 37

P1 November 2014 Question Eight Coding Classification

Question	Mark	Verb	Cognitive Demand Level	CDL code
8.1.1	1	State	Recall	1
8.1.2	3	Draw	Application and analysis	3
8.1.3	1	Interpret	Application and analysis	3
8.1.4	3	Interpret	Application and analysis	3
8.2.1	3	Calculate	Application and analysis	3
8.2.2	3	Calculate	Application and analysis	3
8.2.3	5	Calculate	Application and analysis	3
8.2.4	1	Identify	Recall	1
8.2.5	2	Explain	Comprehension	2

4.6.9 Question Nine Coding Classification.

Question Nine of the P1 November 2014 comprises comprised five sub-questions all based on the electricity and magnetism topic and was accordingly coded PST3. Table 38 shows the coding classification of the P1 November 2014, Question Nine.

Table 38

P1 November 2014 Question Nine Coding Classification

Question	Mark	Verb	Cognitive demand level	CDL code
9.1	1	Name	Recall	1
9.2	1	State	Recall	1
9.3	1	Name	Recall	1
9.4.1	2	Define	Recall	1
9.4.2	3	Calculate	Application and analysis	3

4.6.10 Question Ten Coding Classification.

Question Ten of the P1 November 2014 comprises four sub-questions all based on the optical phenomena topic and was accordingly coded PST4. Table 39 shows the coding classification of P1 November 2014, Question Ten.

Table 39

P1 November 2014 Question Ten Coding Classification

Question	Mark	Verb	Cognitive demand level	CDL code
10.1	2	Define	Recall	1
10.2	5	Calculate	Application and analysis	3
10.3	1	Select	Recall	1
10.4	3	Explain	Comprehension	2

4.7 FINDINGS OF THE P1 NOVEMBER 2014 ANALYSIS.

This section presents the findings of the P1 November 2014 analysis. The findings of the analysis of the P1 March 2015 to P1 March 2018 analysis are presented in Appendix S to Appendix Y. The findings of the P1 November 2014 analysis are presented using the P1 November 2014 physics topic weighting (Table 40), the P1 November 2014 cognitive demand weighting (Table 41), the P1 November 2014 cognitive demand distribution (Figure 19), P1 November 2014 frequency matrix (Table 42), the P1 November 2014 ratio matrix (Table 43), and the CAPS 2014 – P1 November 2014 absolute differences matrix (Table 44).

Table 40 shows that there are 57 questions in the P1 November 2014. The mechanics topic included 23 questions, the waves, sound and light topic included five questions, the electricity and magnetism topic included 24 questions, and the optical phenomena topic included five questions. The physics topic weighting of the P1 November 2014 in decreasing order of frequency is electricity and magnetism (42.1 percent); mechanics (40.4 percent); waves, sound and light (8.8 percent); and optical phenomena (8.8 percent).

Table 40

P1 November 2014 Physics Topic Weighting

Physics topic	PST code	Frequency	Percent
Mechanics	1	23	40.4
Waves, sound and light	2	5	8.8
Electricity and magnetism	3	24	42.1
Optical phenomena	4	5	8.8
Total		57	100.0

The cognitive demand analysis of the P1 November 2014 revealed that the recall cognitive demand included 12 questions, the comprehension cognitive demand included 27 questions, and the application and analysis cognitive demand included 18 questions. The P1 November 2014 did not use the synthesis and evaluation level of the cognitive taxonomy. The cognitive demand weighting of the P1 November 2014 in decreasing order of frequency is application and analysis (50.9 percent); recall (31.6 percent); comprehension (17.5 percent); and synthesis and evaluation (zero percent). Table 41 shows the cognitive demand weighting of the P1 November 2014.

Table 41

P1 November 2014 Cognitive Demand Weighting

Cognitive demand level	CDL code	Frequency	Percent
Recall	1	18	36.1
Comprehension	2	10	17.5
Application and analysis	3	29	50.9
Synthesis and evaluation	4	0	0.0
Total		57	100.0

Figure 19 shows the cognitive demand distribution of the P1 November 2014.

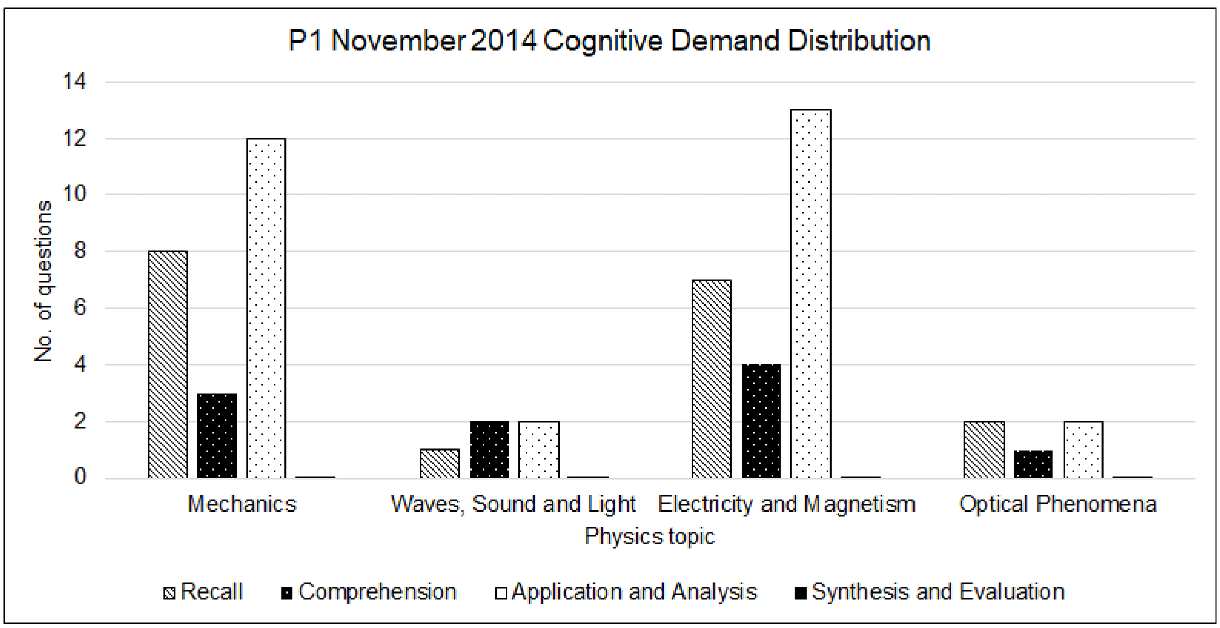


Figure 19. *P1 November 2014 Cognitive Demand Distribution.*

Table 42 shows a tally of each cognitive demand level within each physics topic.

Table 42

P1 November 2014 Frequency Matrix

Physics topic	Cognitive demand level (number of items)				Total
	CDL1	CDL2	CDL3	CDL4	
PST1	8	3	12	0	23
PST2	1	2	2	0	5
PST3	7	4	13	0	24
PST4	2	1	2	0	5
Total	18	10	29	0	57

A cell-by-cell division of the P1 November 2014 frequency matrix (Table 42) by the P1 November 2014 frequency matrix total (57) resulted in the P1 November 2014 ratio matrix (Table 43)

Table 43

P1 November 2014 Ratio Matrix

Physics topic	Cognitive demand level (number of items divided by 57)			
	CDL1	CDL2	CDL3	CDL4
PST1	0.1404	0.0526	0.2105	0.000
PST2	0.0175	0.0351	0.0351	0.000
PST3	0.1228	0.0702	0.2281	0.000
PST4	0.0351	0.0175	0.0351	0.000

The absolute value of the difference between the CAPS 2014 ratio matrix (Table 29) and the P1 November 2014 ratio matrix (Table 43) produced the CAPS 2014 – P1 November 2014 absolute differences matrix. Table 44 shows the CAPS 2014 – P1 2014 absolute differences matrix.

The CAPS 2014 – P1 November 2014 absolute differences matrix total (0.4061) was used in Porter's alignment equation (Section 3.8.1) to calculate the AI (0.7969) between the CAPS 2014 and the P1 November 2014.

Table 44

CAPS 2014 – P1 November 2014 Absolute Differences Matrix

Physics topic	Cognitive demand level (ratio)			
	CDL1	CDL2	CDL3	CDL4
PST1	0.1144	0.0549	0.1221	0.000
PST2	0.0034	0.0349	0.0069	0.000
PST3	0.0256	0.1538	0.0050	0.000
PST4	0.0067	0.0039	0.0105	0.000

CALCULATION OF PORTER'S ALIGNMENT INDEX (AI).

4.8 To calculate the AI between the CAPS 2014 and the P1 November 2014, the sum total of the CAPS 2014 – P1 November 2014 absolute differences matrix (Table 44) was substitued for the term $\sum_{i=1}^{n}|(X_i - Y_i)|$ in Porter's alignment equation. The the total of the CAPS 2014 – P1 November 2014 absolute differences matrix was 0.4061

$$AI = 1 - \frac{\sum_{i=1}^{n}|(X_i - Y_i)|}{2}$$

$$AI = 1 - \frac{0.4061}{2}$$

$$AI = 0.7969$$

The AI calculations for the CAPS (2014 – 2017) and the P1 (March 2015 – March 2018) are presented in Appendix AAto Appendix GG. The results of the AI calculations are presented in Table 45.

Table 45

Alignment Index for the CAPS and the P1

P1	$\sum_{i=1}^{n} \vert (X_i - Y_i) \vert$	AI
November 2014	0.5420	0.7969
March 2015	0.4956	0.8107
November 2015	0.4296	0.7200
March 2016	0.5762	0.7119
November 2016	0.4296	0.7852
March 2017	0.4821	0.7590
November 2017	0.4327	0.7837
March 2018	0.4536	0.7732
Average		0.7676

Note. $\sum_{i=1}^{n} |(X_i - Y_i)|$, absolute differences matrix total. AI, alignment index.

4.9 RESEARCH QUESTIONS.

The main research question of this study is to determine the alignment of the alignment of the P1 (November 2014 - March 2018) and the CAPS. This research question has four quantitative measures of alignment which includes matching Physics topics, relative emphasis of Physics topic coverage, relative emphasis of cognitive demand coverage and the alignment index. Each of the four measures of alignment formed the research sub-questions of this study.

4.9.1 Research Question One.

A physics topic classification of the CAPS, Guidelines and P1 (Appendix C to Appendix O) assisted in answering the first research question: "What is the measure of matching physics topics between the CAPS and the P1 for the period November 2014 to March 2018?" The measure of matching physics topics between the CAPS and the P1 is 100 percent.

4.9.2 Research Question Two.

To answer research question two, “What is the measure of the relative emphasis of physics topics coverage between the CAPS and the P1 for the period November 2014 to March 2018?” a physics topic classification of the CAPS and the P1 was conducted (Appendix C to Appendix O). Table 46 shows the CAPS (2014 – 2017) frequency matrix that was obtained by the cumulative sum of the CAPS frequency matrices from 2014 to 2017.

Table 46

CAPS (2014 – 2017) Frequency Matrix Data

Physics topic	Cognitive demand level (number of items)				Total	Percent
	CDL1	CDL2	CDL3	CDL4		
PST1	225	130	299	0	654	58.3
PST2	16	20	12	0	48	4.3
PST3	108	64	165	0	337	30.1
PST4	32	42	8	0	82	7.3
Total	381	256	484	0	1121	
Percent	34	23	43	0		

Table 47 shows the P1 (November 2014 – March 2018) frequency matrix that was obtained by the cumulative sum of the P1 frequency matrices from November 2014 to March 2018.

Table 47

P1 (November 2014 – March 2018) Frequency Matrix

Physics topic	Cognitive demand level (number of items)				Total	Percent
	CDL1	CDL2	CDL3	CDL4		
PST1	32	39	109	0	180	42.0
PST2	17	13	14	0	44	10.3
PST3	35	40	81	0	156	36.4
PST4	18	11	20	0	49	11.4
Total	102	103	224	0	429	
Percent	24	24	52	0		

Table 48 shows the physics topic distribution in the CAPS and the P1. Column five of Table 48 shows the absolute differences of the each physics topic distribution. The total of the absolute differences is a measure of the mismatch between the physics topics in the CAPS and the P1.

Table 48

CAPS – P1 Physics Topic Classification

Physics topic	PST code	% in CAPS	% in P1	$\lvert$Difference$\rvert$
Mechanics	1	58.3	42.0	16.3
Waves, sound and light	2	4.3	10.3	6.0
Electricity and magnetism	3	30.1	36.4	6.3
Optical phenomena	4	7.3	11.4	4.1
Total		100.0	100.0	32.7

The data of Table 48 was used to construct Figure 20 which shows that the CAPS over-utilises the mechanics topic and the P1 over-utilises the electricity and magnetism topic. The most substantial mismatch of the physics topics occurred within mechanics. The measure of the matching physics topics between the CAPS and the P1 was 67.3 percent (100 percent - 32.7 percent).

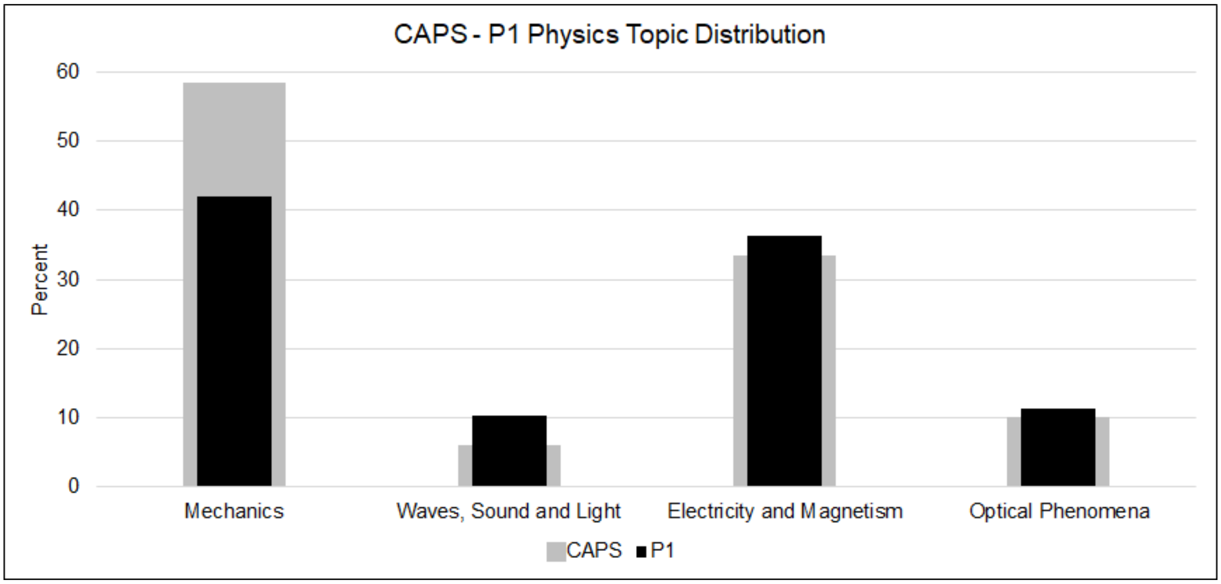


Figure 20. CAPS – P1 Physics Topic Distribution.

4.9.3 Research Question Three.

To answer research question three, "What is the measure of the relative emphasis of the cognitive demand coverage between the CAPS and the P1 for the period November 2014 to March 2018?" A cognitive demand classification of the CAPS (Appendix B) and the P1 was conducted (Appendix H to Appendix O).

Figure 21 illustrates that the CAPS over-utilises the recall cognitive demand and the P1 over-utilises the application and analysis cognitive demand.

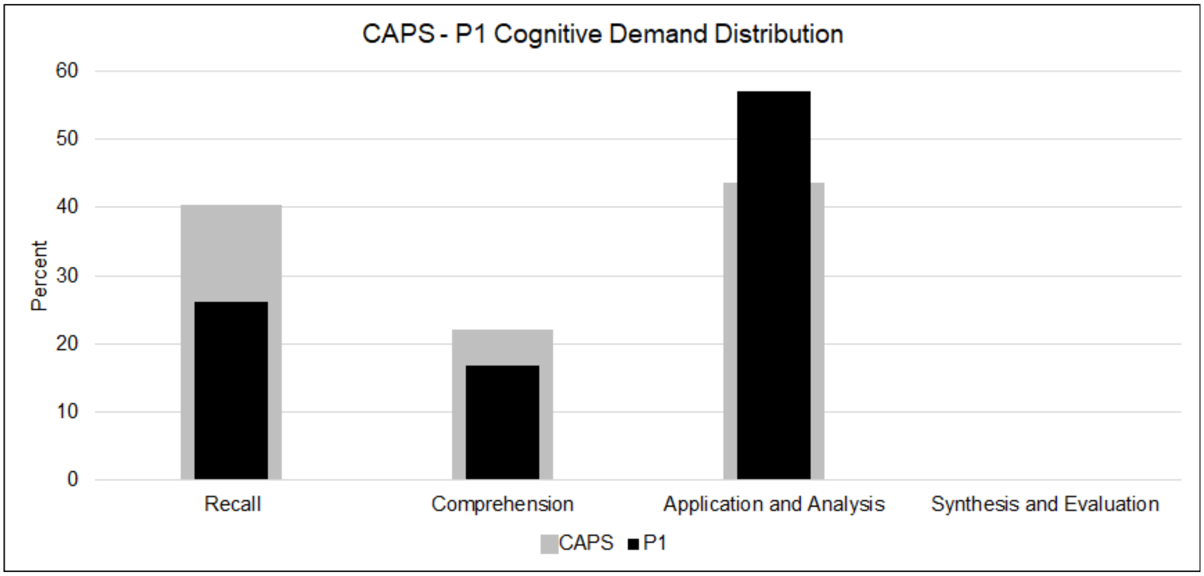


Figure 21. CAPS – P1 Cognitive Demand Distribution.

Table 49 shows that the most substantial mismatch between the CAPS and the P1 occurred in the recall cognitive demand. The measure of the relative emphasis of the cognitive demand coverage between the CAPS and the P1 was 79.6 percent (100 percent - 20.4 percent).

Table 49

CAPS – P1 Cognitive Demand Level Distribution

Cognitive demand	CDL code	% in CAPS	% in P1	|Difference|
Recall	1	34.0	23.8	10.2
Comprehension	2	22.8	24.0	1.2
Application and analysis	3	43.2	52.2	9.0
Synthesis and evaluation	4	0.0	0.0	0.0
Total		100.0	100.0	20.4

Note. Column 5 is the absolute difference between column 3 and column 4.

4.9.4 Research Question Four.

To answer research question four, “What is Porter’s alignment index between the CAPS and the P1 for the period November 2014 to March 2018?”, the CAPS – P1 absolute differences matrix total was substituted into Porter’s alignment equation (Section 3.8.1) to determine the AI.

Table 45 showed the alignment indices of the CAPS and the P1. The average AI between the CAPS and the P1 was 0.7676 for the period November 2014 to March 2018. The lowest AI (0.7119) between the CAPS and the P1 occurred for the March 2016 examination. The highest AI (0.8107) between the CAPS and the P1 occurred in the November 2015 examination. The average AI between the CAPS and the P1 for the final examinations (0.7715) was higher than the average AI between the CAPS and the P1 for the supplementary examinations (0.7637).

4.10 SUMMARY OF CHAPTER FOUR.

This chapter presented the coding and findings for the classification of the CAPS Grade 12 Physics, Guidelines (2014 - 2018) and P1 (November 2014 - March 2018). Table 50 shows that the measure of matching physics topics between the CAPS and the P1 for the period November 2014 to March 2018 was 100 percent. The measure of the relative emphasis of physics topics coverage between the CAPS and the P1 for the period November 2014 to March 2018 was 67 percent. The measure of the relative emphasis of the cognitive demand level coverage between the CAPS and the P1 for the period November 2014 to March 2018 was 90 percent and Porter’s alignment index between the CAPS and the P1 for the period November 2014 to March 2018 was an average of 77 percent.

Table 50

Summary of the Alignment Criteria.

Research question	Alignment criteria	Percent
1	Categorical concurrence	100.0
2	Balance of representation	67.3
3	Cognitive complexity	79.6
4	Porter's alignment index	76.7

Note. Research questions, what is (1) the measure of the relative emphasis of physics topics coverage (2) the measure of the relative emphasis of physics topics coverage (3) the measure of the relative emphasis of the cognitive demand level coverage (4) Porter's alignment index, between the CAPS and the P1 for the period November 2014 to March 2018?

CHAPTER 5

CONCLUSION

5.1 OVERVIEW.

There have been reports about poor learner performance in Grade 12 Physical Sciences being prevalent in the current CAPS based education system (Kriek *et al.*, 2010, p. 185; Kriek *et al.*, 2009, p. 12). A review of the literature studies on alignment studies suggested that there may be a relationship between the degree of alignment between the curriculum and the examination which can describe the current scenario of learner performance (Squires, 2012, p. 129). The assessment of the alignment between the CAPS and the P1 for the period between November 2014 to March 2018 is the aim of this study. This study was guided by four research questions that required to find a measure of matching physics topics; physics topic coverage; cognitive demand coverage and alignment index between the CAPS and the P1.

The methodology used to answer the research questions posed in this study was the SEC method, which included the calculation of Porter's alignment index. The SEC method involved a summative content analysis of the CAPS Grade 12 Physics, Guidelines (2014 – 2017) and P1 (November 2014 – March 2018). The use of a list of verbs to code the documents of this study ensured the validity of the analysis. Instances where the content items of the CAPS and questions of the P1 did not contain an explicit verb, suitable verbs were assigned. An interrater kappa coefficient of 0.88 confirmed the reliability of the classification.

The first document analysed was the CAPS Grade 12 Physics, the physics topic and cognitive demand classification of each content item produced a single frequency matrix. Following the CAPS classification, the physics topic and cognitive demand classification of each content item of the Guidelines (2014 - 2017) resulted in four Guidelines frequency matrices. The CAPS Grade 12 Physics frequency matrix was added to the four Guidelines frequency matrices to produce four CAPS (2014 – 2017) frequency matrices. The third set of documents analysed was the P1 (November 2014 – March 2018), the physics topic and cognitive demand classification of each question in the P1, produced eight P1 frequency matrices. The frequency matrices were used to calculate the categorical concurrence, balance of representation and cognitive complexity between the CAPS and the P1.

A cell-by-cell division of the frequency matrices by each frequency matrix total produced the ratio matrices. The absolute difference between each CAPS – P1 pair of ratio matrices resulted in an absolute differences matrix. The matrix total of the absolute differences matrix was used in Porter's alignment equation to calculate the AI.

5.2 SUMMARY OF FINDINGS.

The first research question: "What is the measure of matching physics topics between the CAPS and the P1 for the period November 2014 to March 2018?" The answer to the first research question involved an analysis of the physics topics in the CAPS and the P1. The findings of the analysis revealed that the CAPS and the P1 (November 2014 - March 2018) have a 100 percent match of physics topics between them.

The second research question: "What is the measure of the relative emphasis of the physics topic coverage between the CAPS and the P1 for the period November 2014 to March 2018?", To answer the second research question, required a physics topic classification of each content item of the CAPS and each question of the P1. The physics topic distribution of the CAPS in decreasing order of frequency is mechanics (58.4 percent); electricity and magnetism (30.1 percent); optical phenomena (7.3 percent); and waves, sound and light (4.3 percent). The physics topic distribution of the P1 in decreasing order of frequency is mechanics (42 percent); electricity and magnetism (36.4 percent); optical phenomena (11.4 percent); and waves, sound and light (10.3 percent). From this data, the relative emphasis of the physics topic coverage between the CAPS and the P1 for the period November 2014 to March 2018 is 67.3 percent.

The third research question: "What is the measure of the relative emphasis of the cognitive demand level coverage between the CAPS and the P1 for the period November 2014 to March 2018?" The answer to the third research question required a cognitive demand level classification of each content item of the CAPS and each question of the P1. The cognitive demand distribution of the CAPS in decreasing order of frequency is application and analysis (43.2 percent); recall (34.0 percent); comprehension (22.8 percent); and synthesis and evaluation (0.0 percent). The cognitive demand distribution of the P1 in decreasing order of frequency is application and analysis (52.2 percent); comprehension (24 percent); recall (23.8 percent); and synthesis and evaluation (0.0 percent). From this data, relative emphasis of the cognitive demand level coverage between the CAPS and the P1 for the period November 2014 to March 2018 is 79.6 percent.

The answer to the fourth research question, "What is Porter's alignment index between the CAPS and the P1 for the period November 2014 to March 2018?". The CAPS – P1 matrix total of the absolute differences matrix was used in Porter's alignment equation to calculate the AI. The AI obtained ranged between 0.71 for the P1 March 2016 and 0.81 for P1 March 2015. The average Porter's alignment index between the CAPS and the P1 for the period November 2014 to March 2018, expressed as a percentage, is 77 percent.

5.3 DISCUSSION OF THE FINDINGS.

The theoretical framework of this study integrates a modified version of Bloom's taxonomy of cognitive demands and Bernstein's pedagogic device to produce the categories of this study. In Bernstein's pedagogic device, the CAPS is part of the field of knowledge reproduction, and the P1 is part of the field of knowledge re-conceptualisation. The assessment also forms part of the classification rules of Bernstein's pedagogic device and is part of the theoretical framework of this study. The assessment classification rule was used twofold, primarily in the selection of the P1 and secondarily by incorporating the EDR into the rationale of this study. The discussion of the findings was made regarding the theoretical framework using the four physics topics and the four levels of cognitive demand as they appear regarding Bernstein's pedagogic device and the modified Bloom's taxonomy.

The use of the four physics topics to measure the categorical concurrence established a 100 percent categorical concurrence between the CAPS and the P1. The significance of a 100 percent matching physics topics implies that all four physics topics prescribed in the CAPS are assessed in the P1. However, this alignment measure did not provide any meaningful insight into the alignment between the CAPS and the P1. For this alignment measure to be more useful, further research must be conducted using the 14 subtopics of mechanics; three subtopics of waves, sound and light; 10 subtopics of electricity and magnetism; and two subtopics of optical phenomena. In addition to the categorical concurrence, the balance of representation also uses the physics topics as a second alignment measure.

There were 1121 items classified in the CAPS and 429 items classified in the P1. Regarding the relative physics topics weighting between the CAPS and the P1, the total discrepancy was 32.7 percent which resulted in a 67.3 percent balance of representation between the CAPS and the P1. The mechanics topic was under-emphasised in the P1 by 16.3 percent, while the waves, sound and light topic, the electricity and magnetism topic and the optical phenomena topic was over-emphasised in the P1 by 6.0 percent, 6.3 percent and 4.1 percent respectively. Although the percentages are relative, the significance of this finding confirms that the topic coverage of mechanics in the P1 was under-emphasised at the expense of the other three physics topics. According to (Webb, 2007, p. 15), balance of representation indices greater than 70 percent are acceptable. The 67.3 percent, balance of representation calculated in this study is below the acceptable value.

The analysis of the cognitive demand level coverage between the CAPS and the P1 revealed that the recall cognitive demand level was under-emphasised in the P1 by 10.2 percent. The comprehension cognitive demand, as well as the application and analysis cognitive demand, were over-emphasised in the P1 by 1.2 percent and 9.0 percent respectively. The total discrepancy of cognitive demands levels was 20.4 percent, which resulted in a 79.6 percent cognitive complexity between the CAPS and the P1. The significance of this finding confirms that the recall cognitive demand was under-emphasised in the P1 at the expense of the comprehension cognitive demand, as well as the application and analysis cognitive demand.

The synthesis and evaluation cognitive demand is utilised in the practical activities of the SBA and although not directly included in the content items of the CAPS, the CAPS makes reference to the practical activities of the SBA. Although the SBA was outside the scope of this study, its inclusion would have decreased the calculated AI, as this study found no P1 questions based on the synthesis and evaluation cognitive demand.

The P1 March 2016 achieved the lowest AI (0.71) while the March 2015 achieved the highest AI (0.79). The eight P1s had an average AI of 0.77 for the period November 2017 to March 2018. The AI is dependent on the number of topics; many cognitive demand levels and the number of content items in the curriculum document, therefore, a calculated AI for a specific set of curriculum and examination documents does not have an interpretive strength. Fulmer (2010) obtained a computational algorithm to calculate simulated mean critical values based on varying the number of topics, cognitive levels and curriculum content items. This study used four topics in physics and four levels of cognitive demand which resulted in a four by four matrix having sixteen cells. The mean simulated AI reference value for 16 cells using 120 curriculum content items was 0.9821 (Fulmer, 2010, p. 396). Using a two-tailed test, at the 0.05 alpha level, the mean simulated AI in the 0.025 and 0.975 quantiles were 0.9664 and 0.9892 respectively. In this study, the computed average AI of 0.7676 was below the 0.025 quantiles at the 95 percent confidence interval. The AI was therefore significantly lower than would be expected by chance at the 0.05 level. Figure 22 shows a comparison between the AI and the levels of cognitive demand indicating some form of inverse relationship between the AI and the application and analysis cognitive demand level.

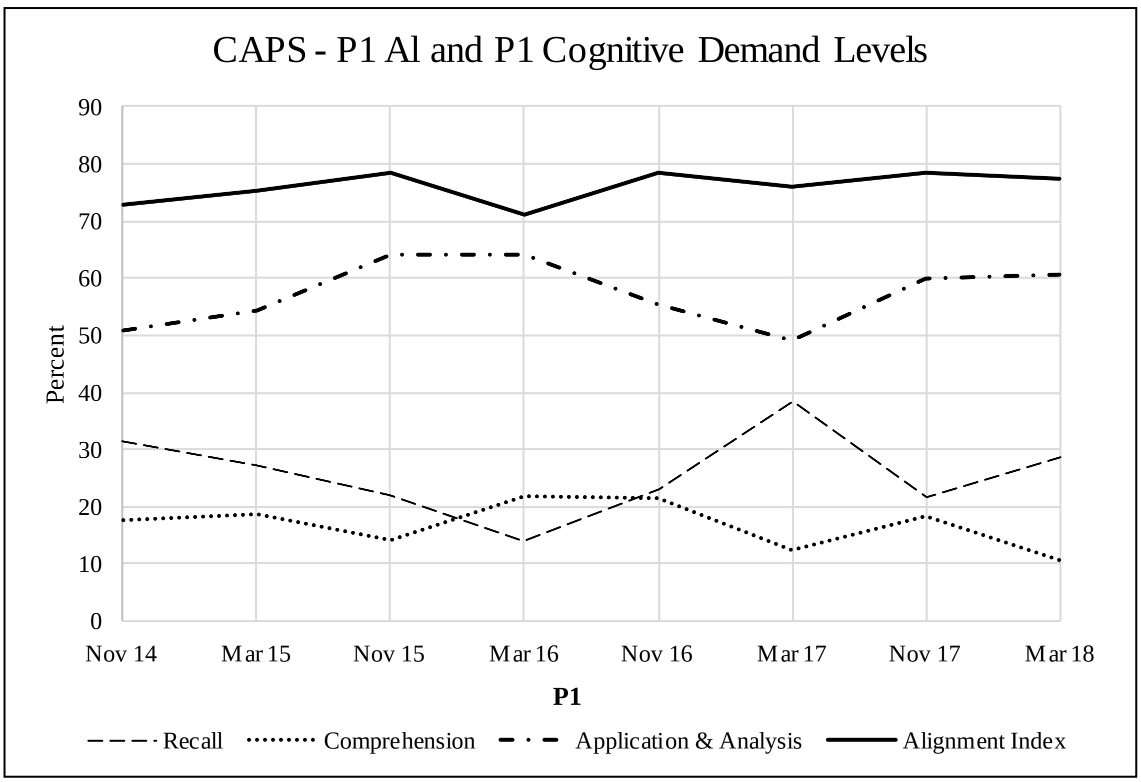


Figure 22. *CAPS – P1 Alignment Index and P1 Cognitive Demand Levels*

An increased application and analysis cognitive demand implies a jointly decreased recall and comprehension cognitive demand, which is the case in the P1 March 2016. In the P1 March 2016, the application and analysis cognitive demand was at its highest weighting, and the AI was at its lowest. This disjoint indicates that the CAPS is weighted heavily on the recall cognitive demand which should not be the case. A list of definitions in the curriculum, supported by a textbook is sufficient enough to cover the concepts of definitions. The curriculum should not become the textbook. The inclusion of concepts covered by the practical investigations would result in a higher alignment between the CAPS and the P1.

The average AI of 0.77 calculated in this study was lower than the AI of 0.80 obtained by Edwards (2010, p. 586) but higher than the average AI of 0.71 and 0.30 obtained by Fulmer *et al.* (2009, p. 787) and by Guo *et al.* (2012, p. 38) respectively. More importantly, the computed average AI of 0.77 was below the critical mean simulated value of 0.98. A low alignment index does not have a negative connotation if it is due to the examination having a higher percentage of questions that are based on higher-order thinking (Fulmer *et al.*, 2009, p. 792). Edwards (2010, p. 587) explained the importance of having a higher frequency of questions based on the recall cognitive demand level as essential for the transfer of knowledge to solve problems based on the Application and analysis cognitive level. There is a disjoint between their alignment. This study recommends that firstly; the CAPS decreases the mechanics topic content. Secondly, the CAPS and the P1 increase the synthesis and evaluation cognitive demand at the expense of the recall cognitive demand and thirdly, the CAPS must include the concepts of the school-based physics practical assessments while decreasing the focus on physics definitions.

5.4 IMPLICATIONS AND RECOMMENDATIONS.

The application and analysis cognitive demand is the most utilised cognitive demand level in the questions of the P1. The verb that described most of these questions was “calculate” which in Bloom’s original taxonomy of cognitive demand was part of the “application” cognitive demand level. The P1 did not utilise the synthesis and evaluation cognitive demand. These findings are in agreement with the study conducted by Mothlabane (2017). In both, the study by Mothlabane (2017) and the current study, the absence of P1 questions based on the synthesis and evaluation cognitive demand is conspicuous.

The recall cognitive demand, comprehension cognitive demand and application cognitive demand formed part of the lower order thinking skills while the analysis cognitive demand and the synthesis and evaluation cognitive demand formed part of the higher order thinking skills (Saido, Siraj, Nordin, & Al-Amedy, 2017, p. 17). The use of everyday thinking and learning can lead to the acquisition of critical thinking skills which are a specialised and systematic form of thinking that involves higher order thinking skills (Young, Lambert, Roberts, & Roberts, 2014, p. 206). Intellectual enquiry forms the basis of critical thinking, and Dewey (1933, p. 5) defined critical thinking as "reflective thought" which involved avoiding making judgements too soon, always maintaining a bit of doubt and being receptive to everything.

This study establishes a quantitative relationship between the CAPS and the P1 in the South African context. Further potential research which was beyond the scope of this study, would be to firstly use the cognitive complexity within the factual, conceptual, procedural, and metacognitive knowledge areas as described by Krathwohl (2002, p. 213) to expand the scope of assessing the alignment between the CAPS and the P1, secondly, to expand the topic coverage by using the 29 sub-topics of physics rather than the four broad physics topics as was the case in this study, thirdly to include the analysis of additional documentation such as the Exemplar P1 examinations and the SBA guidelines to determine the alignment between the CAPS and the P1, fourthly to use P1 examination performance data and topic weighting by mark allocation as another dimension of alignment, fifthly to include the content of the CAPS Grade 10 and Grade 11 Physical Sciences: Physics in the alignment study due to the spiral nature of the curriculum, and finally to obtain an overall view of the alignment in physics by including learner achievement, instruction and professional educator development in the alignment study.

REFERENCES

Anderson, L. W., Krathwohl, D. R., & Bloom, B. S. (2001). *A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives*. New York: Longman.

Ashwin, P. (2014). Knowledge, Curriculum and Student Understanding in Higher Education. *Higher Education*, *67*(2), 123-126. doi:10.1007/s10734-014-9715-3

Baxter, P., & Jack, S. (2008). Qualitative Case Study Methodology: Study Design and Implementation for Novice Researchers. *The Qualitative Report, 13*(4), 544-559. Retrieved from https://nsuworks.nova.edu/tqr/vol13/iss4/2

Bernstein, B. (1977). *Aspects of the Relations between Education and Production* (2 ed.). London: Routledge.

Bernstein, B. (1990). *Class, Codes and Control* (Vol. 4: The structuring of pedagogic discourse). New York, NY: Routledge.

Bertram, C. (2012). Bernstein's Theory of the Pedagogic Device as a Frame to Study History Curriculum Reform in South Africa. *Yesterday and Today*, (7), 1-22. Retrieved from http://sashtw.org.za/Documents/YT/Y&TNo.72012.pdf

Bhuyan, M. H., Khan, S. A., & Rahman, M. Z. (2018). Teaching Digital Electronics Course for Electrical Engineering Students in Cognitive Domain. *International Journal of Learning and Teaching, 10*(1), 1-12. doi:10.18844/ijlt.v10i1

Bloom, B. S. (1956). *Taxonomy of Educational Objectives* (Vol. 1: Cognitive Domain). New York, NY: McKay.

Case, B., & Zucker, S. (2005). *Methodologies for Alignment of Standards and Assessments*. Paper presented at the China-US Conference on Alignment of Assessments and Instruction, Beijing. Retrieved from http://images.pearsonclinical.com/images/PDF/assessmentReports/AlignmentMethodologies.pdf

Case, R. (2013). The Unfortuate Consequences of Bloom's Taxonomy. *Social Education, 77*(4), 196-200. http://0-docserver.ingentaconnect.com.oasis.unisa.ac.za/deliver/connect/ncss/00377724/v77n4/s8.pdf?expires=1533717011&id=0000&titleid=72010569&checksum=338389BA8E873FD593AD68DB500B14F5

Chisholm, L. (2005). The Making of South Africa's National Curriculum Statement. *Journal of Curriculum Studies, 37*(2), 193-208. doi:10.1080/0022027042000236163

Cobbinah, C., & Bayaga, A. (2017). Physics Content and Pedagogical Changes: Ramification of Theory and Practice. *EURASIA Journal of Mathematics, Science and Technology Education, 13*(6), 1633-1651. doi:10.12973/eurasia.2017.00689a

Coleman, V. (2017). On the Reliability of Applying Educational Taxonomies. *Research Matters,* (24), 8-37. http://cambridgeassessment.org.uk/Images/426171-on-the-reliability-of-applying-educational-taxonomies.pdf

Collier, S. (2017, November 23). Top 10 Universities in South Africa 2018. Retrieved from https://www.topuniversities.com/university-rankings-articles/brics-rankings/top-10-universities-south-africa-2018

Creswell, J. W. (2003). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (2nd ed.). Thousand Oaks, CA: Sage.

Cunningham, T., Gannon, J., Kavanagh, M. B., Greene, J., Reddy, L., & Whitson, L. (2007). Theories of Learning and Curriculum Design - Key Positionalities and their Relationships. *Dublin Institute of Technology*. https://arrow.dit.ie/cgi/viewcontent.cgi?article=1035&context=beschrecart

Department of Basic Education (DBE). (2011a). *Curriculum and Assessment Policy Statement Grades 4 - 6 Natural Sciences & Technology*. Retrieved from https://www.education.gov.za/LinkClick.aspx?fileticket=IzbFrpzoQ44%3d&tabid=572&portalid=0&mid=1568&forcedownload=true.

Department of Basic Education (DBE). (2011b). *Curriculum and Assessment Policy Statement Grades 10 - 12 Physical Sciences*. Department of Basic Education. Retrieved from https://www.education.gov.za/LinkClick.aspx?fileticket=uVcOcx728Y8%3d&tabid=570&portalid=0&mid=1558&forcedownload=true.

Department of Basic Education (DBE). (2014a). NSC Grade 12 Physical Sciences: Physics (P1) November 2014. https://www.education.gov.za/LinkClick.aspx?fileticket=s-zwsd8zhjU%3d&tabid=599&portalid=0&mid=1805&forcedownload=true

Department of Basic Education (DBE). (2014b). *Physical Sciences Examination Guidelines Grade 12 2014*. Retrieved from http://www.education.gov.za/Curriculum/CurriculumStatements/FurtherEducationandTraining/Grade122014ExaminationGuidelines/tabid/1153/Default.aspx.

Department of Basic Education (DBE). (2015a). *National Senior Certificate Examination 2014 Diagnostic Report*. Retrieved from https://www.education.gov.za/LinkClick.aspx?fileticket=hZL6MoEQvtQ%3d&tabid=92&portalid=0&mid=4359.

Department of Basic Education (DBE). (2015b). *National Senior Certificate Examination 2014 Schools Performance Report*. Retrieved from https://www.education.gov.za/LinkClick.aspx?fileticket=4JVOD_6ncds%3d&tabid=92&portalid=0&mid=4359.

Department of Basic Education (DBE). (2015c). *Physical Sciences Examination Guidelines Grade 12 2015*. Retrieved from https://www.ecexams.co.za/2015_Assessment_Instructions/AssIn_23_2015_Exam_Guidelines.pdf.

Department of Basic Education (DBE). (2016a). *National Senior Certificate Examination 2015 Diagnostic Report*. Retrieved from https://www.education.gov.za/LinkClick.aspx?fileticket=IwlSo5eiHzA%3d&tabid=92&portalid=0&mid=4359&forcedownload=true.

Department of Basic Education (DBE). (2016b). NSC Grade 12 Physical Sciences: Physics (P1) February/March 2016. https://www.education.gov.za/LinkClick.aspx?fileticket=slrvh3lmb4U%3d&tabid=1000&portalid=0&mid=4411&forcedownload=true

Department of Basic Education (DBE). (2017a, September, 14). About Basic Education. Retrieved from https://www.education.gov.za/AboutUs/AboutDBE.aspx

Department of Basic Education (DBE). (2017b). *NSC Examination Diagnostic Report 2016*. Retrieved from http://www.education.gov.za.

Department of Basic Education (DBE). (2017c). *Physical Sciences Examination Guidelines Senior Certificate Grade 12 2017*. Retrieved from https://www.education.gov.za/LinkClick.aspx?fileticket=o1YziCQ0bEE%3d&tabid=1465&portalid=0&mid=5988.

Department of Basic Education (DBE). (2017d). *Physical Sciences School Based Assessment Exemplars - CAPS Grade 12 Teacher Guide*. Retrieved from https://www.education.gov.za/Portals/0/CD/Curriculum%20doc%20question%20Papers2007/SBA%20Physical%20Science%20Teacher%20Guide.pdf?ver=2014-05-13-143809-000.

Department of Basic Education (DBE). (2018a). *National Senior Certificate Examination 2017 Diagnostic Report Part 1*. Retrieved from https://www.education.gov.za/LinkClick.aspx?fileticket=c4uOac3jwP4%3d&tabid=92&portalid=0&mid=4359&forcedownload=true.

Department of Basic Education (DBE). (2018b). *National Senior Certificate Examination Report 2017*. Retrieved from https://www.education.gov.za/Portals/0/Documents/Reports/2017%20NSC%20Examination%20Report.pdf?ver=2018-01-05-112628-360.

Department of Basic Education (DBE). (2018c). NSC Examinations. Retrieved from https://www.education.gov.za/Curriculum/NationalSeniorCertificate(NSC)Examinations.aspx

Department of Education. (2006). *National Curriculum Statement Grades 10 - 12 Physical Science Content*. Retrieved from http://docscientia.co.za/afr/images/stories/pdf/NATIONALE%20KIRRIKULUM%20VIR%20NCS%20ENG.pdf.

Department of Education Oregon. (1998). *Program Brief on Surveys of Enacted Curriculum*. Salem, Oregon: Office of Educational Improvement and Innovation. Retrieved from http://www.ode.state.or.us/pubs/eii/surveysofenactedcurricbrief.pdf.

Dewey, J. (1933). *How we Think*. Buffalo, NY: Promethus Books.

Dimick, C. (2010). Achieving coding consistency. *Journal of American Health Information Management Association*, *81*(7), 24-28. http://library.ahima.org/xpedio/groups/public/documents/ahima/bok1_047686.hcsp

Duruk, U., Akgüna, A., Doğanb, C., & Gülsuyuc, F. (2017). Examining the Learning Outcomes Included in the Turkish Science Curriculum in Terms of Science Process Skills: A Document Analysis with Standards-Based Assessment. *International Journal of Environmental and Science Education, 12*(2), 117-142. http://files.eric.ed.gov/fulltext/EJ1137380.pdf

Edwards, N. (2010). An Analysis of the Alignment of the Grade 12 Physical Sciences Examination and the Core Curriculum in South Africa. *South African Journal of Education, 30*(4), 571-590. http://www.scielo.org.za/pdf/saje/v30n4/v30n4a05.pdf

Elliott, S. N., Kurz, A., Smithson, J., & Wehby, J. (2010). Alignment of the Intended, Planned, and Enacted Curriculum in General and Special Education and Its Relation to Student Achievement. *44*(3), 131-145. doi:10.1177/0022466909341196

Fulmer, G., Kim, B., Liu, X., Liang, L. L., Yuan, H., & Zhang, B. (2009). Alignment between the Physics Content Standard and the Standardized test: A Comparison Among the United States-New York State, Singapore, and China-Jiangsu. *Science Education, 93*(5), 777-797. doi:10.1002/sce.20330

Fulmer, G. W. (2010). Estimating Critical Values for Strength of Alignment Among Curriculum, Assessments and Instruction. *Journal of Educational and Behavioral Statistics, 36*(3), 381-402. doi:10.3102/1076998610381397

Grussendorff, S., Booyse, C., & Burroughs, E. (2014). *What's in the CAPS package. A Comparative study of the National Curriculum Statement (NCS) and the Curriculum and Assessment Policy Statement (CAPS) Further Education and Training (FET) Phase Overview Report*. Pretoria: Umalusi Retrieved from http://www.umalusi.org.za/docs/reports/2014/Business_Commerce_Management.pdf.

Guba, E., & Lincoln, Y. (1994). Competing Paradigms in Qualitative Research. In N. Denzin & Y. Lincoln (Eds.), *Handbook of Qualitative Research* (pp. 105-117). Thousand Island, CA: Sage Publications.

Guo, Y., Xing, T., Xu, G., & Zheng, C. (2012). Alignment between Physics Curriculum Standard and High School Physics exit Examination in China: A Comparison among Guangdong, Ningxia, Shandong, and Hainan Provinces. *E-Journal of REAL, 3*(2), 29-40. http://realjournal.org/wp-content/uploads/file/2012-2-1-Alignment_Physics_Curriculum_China.pdf

Hallgren, K. A. (2012). Computing inter-rater reliability for observational data: an overview and tutorial. *Tutorials in quantitative methods for psychology, 8*(1), 23. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3402032/pdf/nihms372951.pdf

Harden, R. M. (1999). What is a Spiral Curriculum? *Medical Teacher, 21*(2), 141-143. doi:10.1080/01421599979752

Haridza, R., & Irving, K. (2017). Developing Critical Thinking of Middle School Students using Problem Based Learning 4 Core Areas (PBL4C) Model. *Journal of Physics: Conference Series, 812*(1). doi:10.1088/1742-6596/812/1/012081

Harley, K., & Wedekind, V. (2004). Political Change, Curriculum Change and Social Formation, 1990 to 2002. *Changing Class: Education and Social Change in Post-Apartheid South Africa*, 195-220.

Hattie, J., & Timperley, H. (2007). The Power of Feedback. *Review of Educational Research, 77*(1), 81-112. doi:10.3102/003465430298487

Hays, P. A. (2004). Case Study Research. In K. B. deMarrais & S. D. Lapan (Eds.), *Foundations for Research: Methods of Inquiry in Education and the Social Sciences* (pp. 217-234). Mahwah, NJ: Routledge.

Hinchliffe, G. (2000). Education or Pedagogy? *Journal of Philosophy of Education, 35*(1), 31-45. doi:10.1111/1467-9752.00208

Hoadley, U. (2006). Analysing Pedagogy: The Problem of Framing. *Journal of Education, 40*(1), 15-34.

Hoadley, U., & Jansen, J. D. (2009). *Curriculum: Organizing Knowledge for the Classroom*. Cape Town: Oxford University Press Southern Africa.

Horváthová, D., Rakovská, M., & Zelenický, Ľ. (2017). The Creation of Science Projects in the Physics Teachers Preparation. *AIP Conference Proceedings 2017, 1804*(1), 040004. doi:10.1063/1.4974383

Hsieh, H.-F., & Shannon, S. E. (2005). Three Approaches to Qualitative Content Analysis. *Qualitative Health Research, 15*(9), 1277-1288. doi:10.1177/1049732305276687

Jackson, A. (2016). Finland has one of the world's best education systems. Here's how it compares to the US. Retrieved from https://www.weforum.org/agenda/2016/11/finland-has-one-of-the-worlds-best-education-systems-four-ways-it-beats-the-us

Jansen, J. D. (1998). Curriculum Reform in South Africa: A Critical Analysis of Outcomes-Based Education. *Cambridge Journal of Education, 28*(3), 321-331. doi:10.1080/0305764980280305

Kahl Jr, D. H. (2013). Critical Communication Pedagogy and Assessment: Reconciling two Seemingly Incongruous Ideas. *International Journal of Communication, 7*, 21.

Kennedy, T., & Odell, M. (2014). Engaging Students in STEM Education. *Science Education International, 25*(3), 246-258.

Koh, E., Lee, S. S., Ponnusamy, L. D., Tan, K. C. K., & Tan, L. S. (2017). The Complexities in Fostering Critical Thinking through School-Based Curriculum Innovation: Research Evidence from Singapore. *Asia Pacific Journal of Education, 37*(4), 517-534. doi:10.1080/02188791.2017.1389694

Krathwohl, D. R. (2002). A Revision of Bloom's Taxonomy: An Overview. *Theory into Practice, 41*(4), 212-218. doi:10.1207/s15430421tip4104_2

Kriek, J., Ayene, M., & Damtie, B. (2010). Mismatch between the Progression of the Mathematics Course and the Level of Mathematics required to do Advanced Physics. *Latin-American Journal of Physics Education, 4*(3), 9. Retrieved from https://dialnet.unirioja.es/descarga/articulo/3696853.pdf

Kriek, J., & Grayson, D. (2009). A Holistic Professional Development Model for South African Physical Science Teachers. *South African Journal of Education, 29*(2), 185-203. Retrieved from http://www.scielo.org.za/pdf/saje/v29n2/v29n2a03.pdf

Kuhn, T. S. (1977). *The Essential Tension: Selected Studies in Scientific Tradition and Change*. Chicago: University of Chicago Press.

Leung, L. (2015). Validity, Reliability, and Generalizability in Qualitative Research. *Journal of Family Medicine and Primary Care, 4*(3), 324-327. doi:10.4103/2249-4863.161306

Liang, L. L., & Yuan, H. (2008). Examining the Alignment of Chinese National Physics Curriculum Guidelines and 12th-Grade Exit Examinations: A Case Study. *International Journal of Science Education*, *30*(13), 1823-1835. doi:10.1080/09500690701689766

Maknun, J. (2017). Description of Self-efficacy and Initial Cognitive Abilities on the Students' Physics Learning of the Direct Current Electrical Circuits. *IOP Conference Series: Materials Science and Engineering*, *180*(1), 012041. doi:10.1088/1757-899X/180/1/012041

Malliari, A., & Togia, A. (2017). An Analysis of Research Strategies of articles published in Library Science Journals: The Example of Library and Information Science Research. *Qualitative and Quantitative Methods in Libraries*, *5*(4), 805-818. Retrieved from http://qqml-journal.net/index.php/qqml/article/view/6/6

Martone, A., & Sireci, S. G. (2009). Evaluating Alignment between Curriculum, Assessment, and Instruction. *Review of Educational Research*, *79*(4), 1332-1361. doi:10.3102/0034654309341375

McHugh, M. L. (2012). Interrater reliability: the kappa statistic. *Journal of the Croatian Society of Medical Biochemistry and Laboratory Medicine*, *22*(3), 276-282. Retrieved from https://hrcak.srce.hr/file/132393

Mertens, D. M. (1998). *Research Methods in Education and Psychology: Integrating Diversity with Quantitative & Qualitative Approaches*. Thousand Oaks, CA: Sage Publications.

Mhlolo, M. K., & Venkat, H. (2009). Curriculum Coherence: An Analysis of the National Curriculum Statement for Mathematics (NCSM) and the Exemplar Papers at Further Education and Training (FET) Level in South Africa *African Journal of Research in MST Education*, *13*(1), 33-49. doi:10.1080/10288457.2009.10740649

Mothlabane, A. (2017). Unpacking the South African Physics Examination Questions According to Blooms' Revised Taxonomy. *Journal of Baltic Science Education, 16*(6), 919-931.

Ndlovu, M., & Mji, A. (2012). Alignment between South African mathematics assessment standards and the TIMSS assessment frameworks. *Pythagoras., 33*(3), 9. doi:10.4102/pythagoras.v33i3.182

Opfermann, M., Schmeck, A., & Fischer, H. E. (2017). Multiple Representations in Physics and Science Education–Why Should We Use Them? In *Multiple Representations in Physics Education* (pp. 1-22). Cham (ZG): Springer.

Pellissier, R. (2010). *Research Paradigms and Methodologies*. Paper presented at the Rhodes Research Capacity Workshop, Grahamstown, South Africa. Presentation document retrieved from http://www.ru.ac.za/media/rhodesuniversity/content/facultyofcommerce/documents/Quantitative%20&%20Qualitative%20Slides.pdf

Porter, A. C. (2002). Measuring the Content of Instruction: Uses in Research and Practice. *Educational Researcher, 31*(7), 3-14. doi:10.3102/0013189X031007003

Porter, A. C., Blank, R. K., & Smithson, J. (2001). *New Tools for Analyzing Teaching, Curriculum and Standards in Mathematics & Science. Results from Survey of Enacted Curriculum Project. Final Report*. (1884037739). Washington DC: Council of Chief State Schools. Retrieved from http://files.eric.ed.gov/fulltext/ED458275.pdf.

Porter, A. C., Polikoff, M. S., Zeidner, T., & Smithson, J. (2008). The Quality of Content Analyses of State Student Achievement Tests and State Content Standards. *Educational Measurement: Issues and Practice., 27*(4), 2-14. doi:10.1111/j.1745-3992.2008.00134.x

Potter, W. J., & Levine-Donnerstein, D. (1999). Rethinking Validity and Reliability in Content Analysis. *Journal of Applied Communication Research, 27*(3), 258-284. doi:10.1080/00909889909365539

Resnick, L. B., Rothman, R., Slattery, J. B., & Vranek, J. L. (2004). Benchmarking and Alignment of Standards and Testing. *Educational Assessment, 9*(1-2), 1-27. doi:10.1080/10627197.2004.9652957

Roach, A. T., Elliott, S. N., & Webb, N. L. (2005). Alignment of an Alternate Assessment with State Academic Standards: Evidence for the Content Validity of the Wisconsin Alternate Assessment. *The Journal of Special Education, 38*(4), 218-231. doi:10.1177/00224669050380040301

Roach, A. T., Niebling, B. C., & Kurz, A. (2008). Evaluating the Alignment among Curriculum, Instruction, and Assessments: Implications and Applications for Research and Practice. *Psychology in the Schools, 45*(2), 158-176. doi:10.1002/pits.20282

Rothman, R., Slattery, J. B., Vranek, J. L., & Resnick, L. B. (2002). Benchmarking and Alignment of Standards and Testing. CSE Technical Report. Retrieved from http://files.eric.ed.gov/fulltext/ED466642.pdf

Saido, G. A., Siraj, S., Nordin, A. B., & Al-Amedy, O. S. (2017). Teaching Strategies For Promoting Higher Order Thinking Skills: A Case Of Secondary Science Teachers. *Malaysian Online Journal of Educational Management, 3*(4), 16-30. Retrieved from http://jice.um.edu.my/index.php/MOJEM/article/view/6077/3788

Saracho, O. N. (2017). Theoretical Framework of Developmental Theories of Play. In Tim Waller, Eva Ärlemalm-Hagsér, Ellen Beate Hansen Sandseter, Libby Lee-Hammond, Kristi Lekies, & S. Wyver (Eds.), *The SAGE Handbook of Outdoor Play and Learning*. South Africa: Sage Publications LTD.

Schleicher, A. (2012). *Preparing Teachers and Developing School Leaders for the 21st Century: Lessons from around the World.* Paper presented at the International Summit on the Teaching Profession, Paris, France.

Schmidt, M. J. (2017). The Perils of Outcomes-Based Education in Fostering South African Educational Transformation. *Open Journal of Political Science, 7*(3), 368-379. doi:10.4236/ojps.2017.73030.

Schneider, W., Körkel, J., & Weinert, F. E. (1989). Domain-specific knowledge and memory performance: A comparison of high-and low-aptitude children. *Journal of educational psychology, 81*(3), 306.

Shanks, G. G., & Parr, A. N. (2003). Positivist Single Case Study Research in Information Systems: A Critical Analysis. *ECIS*, 1760-1774. doi:10.1.1.105.8766

Shao, Z. (2018). *Task Design in Mathematics Classrooms*. In Yiming Cao & F. K. S. Leung (Eds.), *New Frontiers in Educational Research. The 21st Century Mathematics Education in China* (pp. 223-237). doi:10.1007/978-3-662-55781-5

Singh, P. (2002). Pedagogising Knowledge: Bernstein's Theory of the Pedagogic Device. *British Journal of Sociology of Education, 23*(4), 571-582. doi:10.1080/0142569022000038422

South African Comprehensive Assessment Institute. (2016). Physical Sciences Examination Guidelines Grade 12 2016. Retrieved from http://auxilio.co.za/documents/StudyAid/Gr12/Gr%2012%20Physical%20Science%20Examination%20Guidelines.pdf

South African Qualifications Authority. (2000). *The National Qualifications Framework and Setting Standards*. Pretoria: South African Qualifications Authority Retrieved from Retrieved from http://saqa.org.za/docs/pol/2003/standard_setting.pdf.

Squires, D. (2012). Curriculum Alignment Research suggests that Alignment can Improve Student Achievement. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas, 85*(4), 129-135. doi:10.1080/00098655.2012.657723

Stake, R. E. (1995). *The Art of Case Study Research*. Thousand Oaks, CA: Sage.

Stanny, C. J. (2016). Reevaluating Bloom's Taxonomy: What Measurable Verbs Can and Cannot Say about Student Learning. *Education Sciences, 6*(4), 37. doi:10.3390/educsci6040037

Stellenbosch University. (2017). 2019 Admission Requirements for Undergraduate Programmes. Retrieved from Available at https://www.sun.ac.za/english/maties/Documents/2018%20Minimumvereistesboekie_Eng.pdf

Traynor, A. (2014). *Examining Alignment Indices' Validity as Measures of Test Content Representativeness.* Michigan State University, Retrieved from https://d.lib.msu.edu/islandora/object/etd:2835/datastream/OBJ/download/Examining_alignment_indices__validity_as_measures_of_test_content_representativeness.pdf

Umalusi. (2017). *Report on the Quality Assurance of the DBE 2017 National Senior Certificate Supplementary Examinations*. Council for Quality Assurance in General and Further Education and Training. Retrieved from http://www.umalusi.org.za/docs/reports/2017/Umalusi%20-BE-NSC-Supplimentrey-QA-Report-2017.pdf.

University of Cape Town. (2017). 2018 Undergraduate Prospectus. Retrieved from Available at http://www.students.uct.ac.za/sites/default/files/image_tool/images/434/prospective/ug_prospectus/ug_prospectus.pdf

University of Johannesburg. (2018). 2019 Undergraduate Prospectus. Retrieved from https://www.uj.ac.za/studyatUJ/sec/Documents/UJ_Undergraduate_Prospectus2019_ONLINE.pdf

University of Kwa-Zulu Natal. (2016). Undergraduate Prospectus 2017. Retrieved from Available at http://applications.ukzn.ac.za/files/2017%20Undergraduate%20Brochure.pdf

University of Potchefstroom. (2017a). 2018/2019 Undergraduate Faculty Brochure. Faculty of Engineering, Built Environment and Information Technology. In.

University of Potchefstroom. (2017b). 2018/2019 Undergraduate Faculty Brochure. Faculty of Health Sciences. In.

University of Witwatersrand. (2018). NSC Admission Requirements. Retrieved from https://www.wits.ac.za/undergraduate/entry-requirements/admission-requirements-nsc/

Wahyuni, D. (2012). The Research Design Maze: Understanding Paradigms, Cases, Methods and Methodologies. *Journal of Applied Management Accounting Research, 10*(1), 69-80. Retrieved from https://papers.ssrn.com/sol3/Delivery.cfm/SSRN_ID2103082_code1209433.pdf?abstractid=2103082&mirid=1

Webb, N. L. (1997). Criteria for Alignment of Expectations and Assessments in Mathematics and Science Education. Monograph No. 6. *National Institute for Science Education, 1*(2), 10.

Webb, N. L. (2007). Issues related to judging the alignment of curriculum standards and assessments. *Applied Measurement in Education, 20*(1), 7-25.

Wilson, M. R., & Bertenthal, M. W. (2005). *Systems for State Science Assessment*. Washington D.C.: National Academies Press.

Wlison, L. O. (2016). The Second Principle. *A succinct discussion of the revisions to Bloom's classic cognitive taxonomy by Anderson and Krathwohl and how to use them effectively*. Retrieved from https://thesecondprinciple.com/teaching-essentials/beyond-bloom-cognitive-taxonomy-revised/

Yahya, Y. (2017, February , 25). Parents put high value on critical thinking, creativity. Retrieved from http://www.straitstimes.com/business/banking/parents-put-high-value-on-critical-thinking-creativity

Yin , R. (1984). *Case Study Research: Design and Methods.* In Vol. 5. *Applied Social Research Methods*. Retrieved from https://pdfs.semanticscholar.org/89c8/30dc397c4d76c8548b8f5f99def607798feb.pdf

Young, M., Lambert, D., Roberts, C., & Roberts, M. (2014). *Knowledge and the Future School: Curriculum and Social Justice*. New York, NY: Bloomsbury Publishing.

Zhang, P., Ding, L., & Mazur, E. (2017). Peer Instruction in Introductory Physics: A Method to bring about Positive Changes in Students' Attitudes and Beliefs. *Physical Review Physics Education Research, 13*(1), 100-104. doi:10.1103/PhysRevPhysEducRes.13.010104

Zhang, Y., & Wildemuth, B. M. (2009). Qualitative Analysis of Content. In B. Wildemuth (Ed.), *Application of Social Research Methods to Questions in Information and Library Science.* (pp. 309-311). Westport, CT: Libraries Unlimited.

APPENDIX

Appendix A. Classification Instrument for P1.

	P1	Month	Year
Question	Mark	PST	CDL

Appendix B. Classification Instrument for the CAPS.

Physics topics		
Subtopic	Content, concepts and skills.	CDL

Mechanics		
Subtopic	Content, concepts and skills	CDL
Resultant of perpendicular vectors	On a Cartesian plane, draw a sketch of the vertical (y-axis) and horizontal (x-axis)	3
	Add co-linear vertical vectors and co-linear horizontal vectors to obtain the net vertical vector (R_y) and net horizontal vector (R_x)	3
	Sketch R_x and R_y on a Cartesian plane	3
	Sketch the resultant (R) using either the tail-to-head or tail-to-tail method.	3
	Determine the magnitude of the resultant using the theorem of Pythagoras.	3
	Find resultant vector graphically using the tail-to-head method as well as by calculation (by component method) for a maximum of four force vectors in both 1-Dimension and 2-Dimension	3
	Understand what is a closed vector diagram	2
Resolution of a vector into its components	Draw a sketch of the vector on the Cartesian plane showing its magnitude and the angle θ between the vector and the x-axis	3
	Use R_x= Rcosθ for the resultant x-component	3
	Use R_y= Rsinθ for the resultant y-component	3
Force diagrams and free body diagrams	Know that a force diagram is a picture of the object(s) of interest with all the forces acting on it drawn in as arrows	1
	Know that in a free-body diagram, the object of interest is drawn as a dot and all the forces acting on it are drawn as arrows pointing away from the dot	1
	Resolve two-dimensional forces (such as the weight of an object with respect to the inclined plane) into its parallel (x) and perpendicular (y) components	3
	The resultant or net force in the x-direction is a vector sum of all the components in the x-direction	1
	The resultant or net force in the y-direction is a vector sum of all the components in the y-direction	1
Newton's Laws of Motion	State Newton's first law: An object continues in a state of rest or uniform (moving with constant velocity unless it is acted upon by an unbalanced (net or resultant) force.	1
	Discuss why it is important to wear seatbelts using Newton's first law	2
	State Newton's second law: When a net force, F_{net}, is applied to an object of mass, m, it accelerates in the direction of the net force. The acceleration, a, is directly proportional to the net force and inversely proportional to the mass	1

Coding of the CAPS Grade 12 Physics continued.

Mechanics		
Subtopic	Content, concepts and skills	CDL
Newton's Laws of Motion	Draw force diagrams for objects that are in equilibrium (at rest or moving with constant velocity) and accelerating (non-equilibrium)	3
	Draw free body diagrams for objects that are in equilibrium (at rest or moving with constant velocity) and accelerating (non-equilibrium)	3
	Apply Newton's laws to a variety of equilibrium and non-equilibrium problems including a single object moving on a horizontal/ inclined plane (frictionless and rough), vertical motion (lifts, rockets etc.) and also two-body systems such as two masses joined by a light (negligible mass) string	3
	Understand apparent weight	2
	State Newton's third law: When object A exerts a force on object B, object B simultaneously exerts an oppositely directed force of equal magnitude on object A	1
	Identify action-reaction pairs, e.g. donkey pulling a cart, a book on a table	1
	List the properties of action-reaction pairs	1
	Define normal force, N, as the force exerted by a surface on an object in contact with it	1
	Know that the normal force acts perpendicular to the surface irrespective of whether the plane is horizontal or inclined	1
	Define frictional force, f, as the force that opposes the motion of an object and acts parallel to the surface the object is in contact with	1
	Distinguish between static and kinetic friction forces	2
	Explain what is meant by the maximum static friction, f_{smax}	2
	Calculate the value of the maximum static frictional force for objects at rest on a horizontal and inclined plane using: $F_smax = u_sN$	3
	Know that static friction $f_s < u_sN$	1
	Calculate the value of the kinetic friction force for a moving object on horizontal and inclined planes using $F_k = u_kN$	3
Newton's Law of Universal Gravitation	State Newton's Law of Universal Gravitation	1
	Use the equation for Newton's Law of Universal Gravitation to calculate the force masses exert on each other	3
	Describe weight as the gravitational force the Earth exerts on any object on or near its surface	2
	Calculate the acceleration due to gravity on Earth using $g = Gm_e/r^2$	3

Coding of the CAPS Grade 12 Physics continued.

Mechanics		
Subtopic	Content, concepts and skills	CDL
Law of Universal Gravitation	Calculate weight using the expression W= mg, where g is the acceleration due to gravity. Near the earth, the value is approximately 9.8 m.s-2	3
	Calculate the weight of an object on other planets	3
	Distinguish between mass and weight. Know that the unit of weight is the Newton (N) and that of mass is the kilogram (kg)	2
	Understand weightlessness	2
Momentum	Define momentum	1
	Calculate the momentum of a moving object using p = mv	3
	Describe the vector nature of momentum and illustrate with some simple examples	1
Conservation of momentum	Draw vector diagrams to illustrate the relationship between the initial momentum, the final momentum and the change in momentum in each of the above cases	3
	State Newton's second law in terms of momentum	1
	Express Newton's second law in symbols $F_{net} = \Delta P/\Delta t$	1
	Explain the relationship between net force and change in momentum for a variety of motions	2
	Calculate the change in momentum when a resultant force acts on an object and its velocity increases in the direction of motion (e.g.2nd stage rocket engine fires), decreases(e.g. brakes are applied), reverses its direction of motion, e.g. a soccer ball kicked back in the direction it came from	3
	Explain what is meant by a system (in physics)	2
	Explain (when working with systems) what is meant by internal and external forces	2
	State the law of conservation of momentum as The total linear momentum of an isolated system remains constant (is conserved)	1
	Distinguish between elastic and inelastic collisions	2
	Know that kinetic energy is only conserved in an elastic collision	1
Impulse	Apply the conservation of momentum to collisions of two objects moving in one dimension (along a straight line) with the aid of an appropriate sign convention	3
	Define impulse as the product of the net force and the contact time, i.e. impulse = $F_{net}.\Delta t$	1
	Know that impulse is a vector quantity	1

Coding of the CAPS Grade 12 Physics continued.

Mechanics		
Subtopic	Content, concepts and skills	CDL
Impulse	Know that $F_{net}.\Delta t$ is a change in momentum.	1
	Use the impulse-momentum theorem to calculate the force exerted, time for which the force is applied and change in momentum for a variety of situations involving the motion of an object in one dimension	3
	Apply the concept of impulse to safety in everyday life, e.g. airbags, seatbelts and arrestor beds	3
1D Vertical projectile motion	Explain that projectiles fall freely with gravitational acceleration 'g' accelerate downwards with a constant acceleration irrespective of whether the projectile is moving upward or downward or is at maximum height	2
	Know that projectiles take the same time to reach their greatest height from the point of upward launch as the time they take to fall back to the point of launch. This is known as time symmetry	1
	Know that projectiles can have their motion described by a single set of equations for the upward and downward motion	1
	Use equations of motion to determine the position, velocity and displacement of a projectile at any given time	3
	Draw position vs. time (x vs. t), velocity vs. time (v vs. t) and acceleration vs. time (a vs. t) graphs for 1D projectile motion	3
	Give equations for position versus time and velocity versus time for the graphs of 1D projectile motion	1
	Given x vs. t, v vs. t or a vs. t graphs determine position, displacement, velocity or acceleration at any time t.	3
	Given x vs. t, v vs. t or a vs. t graphs describe the motion of the object, e.g. graphs showing a ball, bouncing, thrown vertically upwards, thrown vertically downward, and so on	3
Definition of Work	Define the work done on an object by a force as $W=F\Delta xCos\theta$.	1
	Know that work is a scalar quantity and is measured in joules (J)	1
	Calculate the net work done on an object by applying the definition of work to each force acting on the object while it is being displaced, and then adding up (scalar) each contribution	3
	Positive net work done on a system will increase the energy of the system and negative net work done on the system will decrease the energy of the system	1
	Draw a force diagram showing only forces that act along the plane. Ignore perpendicular forces	3

Coding of the CAPS Grade 12 Physics continued.

Mechanics		
Subtopic	Content, concepts and skills	CDL
Work-Energy Theorem	Know that the net work done on an object causes a change in the object's kinetic energy - the work-energy theorem – $W_{net} = E_{kf} - E_{ki}$	1
	Apply the work-energy theorem to objects on horizontal and inclined planes (frictionless and rough)	3
Conservation of energy with non-conservative forces present	Define non-conservative forces and give examples	1
	Know that when only conservative forces are present, mechanical energy is conserved	1
	Know that when non- conservative forces are present mechanical energy (sum of kinetic and potential) is not conserved, but total energy (of the system) is still conserved	1
	Solve problems using equation: $W_{nc} = \Delta E_k + \Delta E_p$	3
	Use the above relationship to show that in the absence of non-conservative forces, mechanical energy is conserved	3
Power	Define power as the rate at which work is done	1
	Calculate the power involved when work is done	3
	Understand the average power required to keep an object moving at a constant speed along a rough horizontal surface or a rough inclined plane and do calculations using $P_{ave}=F.v_{ave}$	2
	Calculate the minimum power required of an electric motor to pump water from a borehole of a particular depth at a particular rate using $P_{ave} = F.v_{ave}$	3

Waves, sound and light		
Subtopic	Content, concepts and skills	CDL
Sound and ultrasound	State the Doppler Effect for sound and give everyday examples.	1
	Explain (using appropriate illustrations) why a sound increases in pitch when the source of the sound travels towards a listener and decreases in pitch when it travels away	2
	Use the equation $f_L = ((v \pm v_L)/(v \pm v_S)).f_S$ to calculate the frequency of sound detected by a listener (L) when EITHER the source or the listener is moving	3
	Describe applications of the Doppler Effect with ultrasound waves in medicine, e.g. to measure the rate of blood flow or the heartbeat of a foetus in the womb	2

Coding of the CAPS Grade 12 Physics continued.

Waves, sound and light		
Subtopic	Content, concepts and skills	CDL
With light - redshifts in the universe	State that light emitted from many stars is shifted toward the red, or longer wavelength/lower frequency, end of the spectrum due to movement of the source of light	1
	Apply the Doppler Effect to these "redshifts" to conclude that most stars are moving away from Earth and therefore the universe is expanding	3

Electricity and magnetism		
Subtopic	Content, concepts and skills	CDL
Coulombs Law	State Coulomb's Law, which can be represented mathematically as F=kQ1Q2/r2	1
	Solve problems using Coulomb's Law to calculate the force exerted on a charge by one or more charges in one dimension (1D) and two dimensions (2D).	3
Electric Fields	Describe an electric field as a region of space in which an electric charge experiences a force. The direction of the electric field at a point is the direction that a positive test charge would move if placed at that point	2
	Draw electric field lines for various configurations of charges	3
	Define the magnitude of the electric field at a point as the force per unit charge E = F/q, E and F are vectors	1
	Deduce that the force acting on a charge in an electric field is F = q.E	3
	Calculate the electric field at a point due to a number of point charges, using the equation $E=k.Q/r^2$ to determine the contribution to the field due to each charge	3
Magnetic fields around conductors	Provide evidence for the existence of a magnetic field (B) near a current carrying wire	3
	Use the Right-Hand Rule to determine the magnetic field (B) associated with: (i) a straight current-carrying wire, (ii) a current carrying loop (single) of wire and (iii) a solenoid	3
	Draw the magnetic field lines around (i) a straight current-carrying wire, (ii) a current carrying loop (single) of wire and (iii) a solenoid	3
	Discuss qualitatively the environmental impact of overhead electrical cables	2
Faradays Law	State Faraday's Law.	1
	Use words and pictures to describe what happens when a bar magnet is pushed into or pulled out of a solenoid connected to a galvanometer	2

Coding of the CAPS Grade 12 Physics continued.

Electricity and magnetism		
Subtopic	Content, concepts and skills	CDL
Faradays Law	Use the Right-Hand Rule to determine the direction of the induced current in a solenoid when the north or south pole of a magnet is inserted or pulled out	3
	Know that for a loop of area A in the presence of a uniform magnetic field B, the magnetic flux (Ø) passing through the loop is defined as Ø = B.A.cosθ, where θ is the angle between the magnetic field B and the normal to the loop of area A	1
	Know that the induced current flows in a direction so as to set up a magnetic field to oppose the change in magnetic flux	1
	Calculate the induced emf and induced current for situations involving a changing magnetic field using the equation for Faraday's Law: where ∅=B.A.cosθ is the magnetic flux	3
Ohms Law	Determine the relationship between current, voltage and resistance at constant temperature	3
	State the difference between Ohmic and non-ohmic conductors	1
	Give an example of ohmic and non-ohmic conductors	3
	Solve problems using the mathematical expression of Ohm's Law, R=V/I, for series and parallel circuits	3
Electrical energy and power	Define power as the rate at which electrical energy is converted in an electric circuit and is measured in watts	1
	Know that electrical power dissipated in a device is equal to the product of the potential difference across the device and current flowing through it, i.e. P=IV	1
	Know that power can also be given by P=I2R or P=V2/R	1
	Solve circuit problems involving the concept of power	3
	Know that the electrical energy is given by E=Pt and is measured in joules (J)	1
	Solve problems involving the concept of electrical energy	3
	Know that the kilowatt-hour (kWh) refers to the use of 1 kilowatt of electricity for 1 hour	1
	Calculate the cost of electricity usage given the power specifications of the appliance used and the duration, given the cost of 1 kWh	3
Internal resistance and series- and parallel networks	Solve problems involving current, voltage and resistance for circuits containing arrangements of resistors in series and in parallel	3
	State that a real battery has internal resistance	1
	The sum of the voltages across the external circuit plus the voltage across the internal resistance is equal to the emf: $\varepsilon = V_{load} + V_{ext}$ or $\varepsilon = I.R + I.r_{ext}$	3

Coding of the CAP Grade12 Physics continued.

Electricity and magnetism		
Subtopic	Content, concepts and skills	CDL
Electrical machines (generators, motors)	Solve circuit problems with an internal resistance of the battery	3
	Solve circuit problems, with internal resistance, involving series-parallel networks of resistors	3
	State that generators convert mechanical energy to electrical energy and motors convert electrical energy to mechanical energy	1
	Use Faraday's Law to explain why a current is induced in a coil that is rotated in a magnetic field.	3
	Use words and pictures to explain the basic principle of an AC generator (alternator) in which a coil is mechanically rotated in a magnetic field	2
	Use words and pictures to explain how a DC generator works and how it differs from an AC generator	2
	Explain why a current- carrying coil placed in a magnetic field (but not parallel to the field) will turn by referring to the force exerted on moving charges by a magnetic field and the torque on the cord	2
	Use words and pictures to explain the basic principle of an electric motor.	2
	Give examples of the use of AC and DC generators and motors	3
Alternating current	Explain the advantages of alternating current	2
	Write expressions for the current and voltage in an AC circuit	1
	Define the rms (root mean square) current as $I_{rms} = I_{max}/\sqrt{2}$ and voltage as $V_{rms} = V_{max}/\sqrt{2}$ respectively, and explain why these values are useful	1
	Know that the average power is given by: $P_{av} = I_{rms}.V_{rms} = ½.I_{max}.V_{max}$	1
	Draw a graph of voltage vs time and current vs time for an AC circuit.	3
	Solve problems using the concepts of I_{rms} ,V_{rms}, P_{av}	3

Optical phenomena		
Subtopic	Content, Concepts and Skills	CDL
Photoelectric effect	Describe the photoelectric effect as the process that occurs when light shines on a metal, and it ejects electrons	2
	The significance of the photo-electric effect: it establishes the quantum theory, and it illustrates the particle nature of light	2
	Define cut-off frequency, f_o	1
	Define work function and know that the work function is material specific	1

Coding of the CAPS Grade 12 Physics continued.

Optical phenomena		
Subtopic	Content, Concepts and Skills	CDL
	Know that the cut-off frequency corresponds to a maximum wavelength	1
	Apply the photo-electric equation: $E = W_o + E_{kmax}$, where $E = h_f$ and $Wo = hf_o$ and $E_{kmax} = ½mv_{max}^2$	3
	Know that the number of electrons ejected per second increases with the intensity of the incident radiation	1
	Know that if the frequency of the incident radiation is below the cut-off frequency, then increasing the intensity of the radiation has no effect, i.e. it does not cause electrons to be ejected	1
	Understand that the photoelectric effect demonstrates the particle nature of light	2
Emission and absorption spectra	Explain the source of atomic emission spectra (of discharge tubes) and their unique relationship to each element	2
	Relate the lines on the atomic spectrum to electron transitions between energy levels	2
	Explain the difference between of atomic absorption and emission spectra	2

Mechanics		
Subtopic	Content, Concepts and Skills	CDL
Newton's laws and application of Newton's laws	Different kinds of forces: weight, normal force, frictional force, applied force (push, pull), tension (strings or cables)	
	Define *normal force*, N, as the force or the component of a force which a surface exerts on an object with which it is in contact, and which is perpendicular to the surface.	1
	Define *frictional force*, f, as the force that opposes the motion of an object and which acts parallel to the surface.	1
	Define *static frictional force*, fs, as a force that opposes the tendency of motion of a stationary object relative to a surface.	1
	Define *kinetic frictional forc*e, fk, as the force that opposes the motion of a moving object relative to a surface.	1
	Know that a frictional force:	
	is proportional to the normal force	1
	is independent of the area of contact	1
	is independent of the velocity of motion	1
	Solve problems using fmaxs = μsN where fmaxs is the maximum static frictional force and μs is the coefficient of static friction	
	if a force, F, applied to a body parallel to the surface does not cause the object to move, F is equal in magnitude to the static frictional force.	3
	the static frictional force is a maximum (fmaxs) just before the object starts to move across the surface.	3
	If the applied force exceeds f_{max}s, a resultant/net force accelerates the object.	3
	Solve problems using $f_k = \mu_k N$, where f_k is the kinetic frictional force and μk the coefficient of kinetic friction.	3
	Force diagrams, free-body diagrams	
	Draw force diagrams.	3
	Draw free-body diagrams. (This is a diagram that shows the relative magnitudes and directions of forces acting on a body/particle that has been isolated from its surroundings)	3
	Resolve a two-dimensional force (such as the weight of an object on an inclined plane) into its parallel (x) and perpendicular (y) components.	3
	Determine the resultant/net force of two or more forces.	3
	Newton's first, second and third laws of motion	
	State Newton's first law of motion: A body will remain in its state of rest or motion at constant velocity unless a non-zero resultant/net force acts on it.	1

Coding of the Guidelines 2014 continued.

Mechanics		
Subtopic	Content, Concepts and Skills	CDL
	Discuss why it is important to wear seatbelts using Newton's first law.	2
Newton's laws and application of Newton's laws	State Newton's second law of motion: When a resultant/net force acts on an object, the object will accelerate in the direction of the force at an acceleration directly proportional to the force and inversely proportional to the mass of the object.	1
	Draw force diagrams and free-body diagrams for objects.	3
	Apply Newton's laws of motion to a variety of including:	
	A single object:	
	Moving on a horizontal plane with or without friction	3
	Moving on an inclined plane with or without friction	3
	Moving in the vertical plane (lifts, rockets, etc.)	3
	Two-body systems (joined by a light inextensible string):	
	Both on a flat horizontal plane with or without friction	3
	One on a horizontal plane with or without friction, and a second hanging vertically from a string over a frictionless pulley	3
	Both on an inclined plane with or without friction	3
	Both hanging vertically from a string over a frictionless pulley	3
	State Newton's third law of motion: When one body exerts a force on a second body, the second body exerts a force of equal magnitude in the opposite direction on the first body.	1
	Identify action-reaction pairs.	1
	List the properties of action-reaction pairs.	1
	Newton's Law of Universal Gravitation	
	State Newton's Law of Universal Gravitation: Each body in the universe attracts every other body with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centres.	1
	Solve problems using F=Gm1m1/r2.	3
	Calculate acceleration due to gravity on a planet using g = Gm/r2	3
	Describe weight as the gravitational force the Earth exerts on any object	2
	Calculate weight using the expression w = mg.	3
	Calculate the weight of an object on other planets with different values of gravitational acceleration.	3
	Distinguish between mass and weight.	2
	Explain weightlessness.	2

Coding of the Guidelines 2014 continued.

Mechanics		
Subtopic	Content, concepts and skills	CDL
Momentum and Impulse	Momentum	
	Define momentum as the product of an object's mass and its velocity.	1
	Describe the linear momentum of an object as a vector quantity with the same direction as the velocity of the object.	2
	Calculate the momentum of a moving object using p = mv.	3
	Describe the vector nature of momentum and illustrate it with some simple examples.	2
	Draw vector diagrams to illustrate the relationship between the initial momentum, the final momentum and the change in momentum for each of the above examples.	3
	Newton's second law of motion in terms of momentum	
	State Newton's second law of motion in terms of momentum: The resultant/net force acting on an object is equal to the rate of change of momentum of the object in the direction of the resultant/net force.	1
	Express Newton's second law of motion in symbols: Fnet= $\Delta p/\Delta t$.	2
	Calculate the change in momentum when a resultant/net force acts on an object and its velocity:	
	Increases in the direction of motion, e.g. 2nd stage rocket engine fires	3
	Decreases, e.g. brakes are applied	3
	Reverses its direction of motion, e.g. a soccer ball kicked back in the direction it came from	3
	Impulse	
	Define impulse as the product of the resultant/net force acting on an object and the time the resultant/net force acts on the object.	1
	Deduce the impulse-momentum theorem: $F_{net}\Delta t = m\Delta v$.	2
	Use the impulse-momentum theorem to calculate the force exerted, the time for which the force is applied and the change in momentum for a variety of situations involving the motion of an object in one dimension.	3
	Explain how the concept of impulse applies to safety considerations in everyday life, e.g. airbags, seatbelts and arrestor beds.	2
	Conservation of momentum and elastic and inelastic collisions	
	Explain what is meant by a closed/an isolated system (in Physics), i.e. a system on which the resultant/net external force is zero. A closed/an isolated system excludes external forces that originate outside the colliding bodies, e.g. friction. Only internal forces, e.g. contact forces between the colliding objects, are considered.	2

Coding of the Guidelines 2014 continued.

Mechanics		
Subtopic	Content, concepts and skills	CDL
Momentum and Impulse	State the principle of conservation of linear momentum: The total linear momentum of a closed system remains constant (is conserved).	1
	Apply the conservation of momentum to the collision of two objects moving in one dimension (along a straight line) with the aid of an appropriate sign convention.	3
	Distinguish between elastic collisions and inelastic collisions by calculation.	2
Vertical Projectile Motion in One Dimension (1D)	Explain what is meant by a projectile, i.e. an object upon which the only force acting is the force of gravity.	2
	Use equations of motion to determine the position, velocity and displacement of a projectile at any given time.	3
	Sketch position versus time (x vs. t), velocity versus time (v vs. t) and acceleration versus time (a vs. t) graphs for:	
	A free-falling object	
	An object thrown vertically upwards	3
	An object thrown vertically downwards	3
	Bouncing objects (restricted to balls)	3
	For a given x vs. t, v vs. t or a vs. t graph, determine:	
	Position	2
	Displacement	2
	Velocity or acceleration at any time t	2
	For a given x vs. t, v vs. t or a vs. t graph, describe the motion of the object:	
	Bouncing	2
	Thrown vertically upwards	2
	Thrown vertically downward	2
Work, Energy and Power	Work	
	Define the work done on an object by a constant force F as FxΔcosθ, where F is the magnitude of the force, xΔ the magnitude of the displacement and θ the angle between the force and the displacement. (Work is done by a force on an object – the use of 'work is done against a force', e.g. work done against friction, should be avoided.)	1
	Draw a force diagram and free-body diagrams.	3
	Calculate the net/total work done on an object.	3
	Distinguish between positive net/total work done and negative net/total work done on the system.	2

Coding of the Guidelines 2014 continued.

Mechanics		
Subtopic	Content, concepts and skills	CDL
Work, Energy and Power	Work-energy theorem	
	State the work-energy theorem: The net/total work done on an object is equal to the change in the object's kinetic energy OR the work done on an object by a resultant/net force is equal to the change in the object's kinetic energy. $W_{net} = \Delta K = K_f - K_i$.	1
	Apply the work-energy theorem to objects on horizontal, vertical and inclined planes (for both frictionless and rough surfaces).	3
	Conservation of energy with non-conservative forces present	
	Define a conservative force as a force for which the work done in moving an object between two points is independent of the path taken. Examples are gravitational force, the elastic force in a spring and electrostatic forces (Coulomb forces).	1
	Define a non-conservative force as a force for which the work done in moving an object between two points depends on the path taken. Examples are frictional force, air resistance, tension in a chord, etc.	1
	State the principle of conservation of mechanical energy: The total mechanical energy (sum of gravitational potential energy and kinetic energy) in an isolated system remains constant. (A system is isolated when the resultant/net external force acting on the system is zero.)	1
	Solve conservation of energy problems using the equation: $Wnc = \Delta Ek + \Delta Ep$	3
	Use the relationship above to show that in the absence of non-conservative forces, mechanical energy is conserved.	2
	Power	
	Define power as the rate at which work is done, or energy is expended. $P = W/\Delta t$	1
	Calculate the power involved when work is done.	3
	Perform calculations using $P_{ave} = Fv_{ave}$ when an object moves at a constant speed along a rough horizontal surface or a rough inclined plane.	3
	Calculate the power output for a pump lifting a mass (e.g. lifting water through a height at constant speed)	3

Coding of the Guidelines 2014 continued.

Waves, sound and light		
Subtopic	Content, concepts and skills	CDL
Doppler Effect	Doppler effect	
	With sound and ultrasound	
	State the Doppler effect as the change in frequency (or pitch) of the sound detected by a listener because the sound source and the listener have different velocities relative to the medium of sound propagation.	1
	Explain (using appropriate illustrations) the change in pitch observed when a source moves toward or away from a listener.	2
	Solve problems using the equation fl=(v±vl/v±vs)fs when EITHER the source or the listener is moving.	3
	State applications of the Doppler effect.	1
	With light – redshifts in the universe (evidence for the expanding universe)	
	Explain redshifts and blue shifts using the Doppler Effect.	2
	Use the Doppler effect to explain why we conclude that the universe is expanding.	2

Electricity and magnetism		
Subtopic	Content, concepts and skills	CDL
Electro-statics	Coulomb's law	
	State Coulomb's law: The magnitude of the electrostatic force exerted by one point charge (Q_1) on another point charge (Q_2) is directly proportional to the product of the magnitudes of the charges and inversely proportional to the square of the distance (r) between them:	1
	Solve problems using the equation $F = kQ_1Q_2/r^2$ for charges:	
	in one dimension (1D) (restrict to three charges).	3
	in two dimensions (2D) – for three charges in a right-angled formation (limit to charges at the 'vertices of a right-angled triangle').	3
	Electric field	
	Describe an electric field as a region of space in which an electric charge experiences a force. The direction of the electric field at a point is the direction that a positive test charge would move if placed at that point.	2
	Draw electric field patterns for the following configurations:	
	A single point charge	3
	Two point charges (1 negative, 1 positive OR 2 positive OR 2 negative)	3
	A charged sphere	3

Coding of the Guidelines 2014 continued.

Electricity and magnetism		
Subtopic	Content, concepts and skills	CDL
Electro-statics	Define the electric field at a point: The electric field at a point is the electrostatic force experienced per unit positive charge placed at that point. In symbols: E = F / Q	1
	Solve problems using the equation E = F /Q	3
	Calculate the electric field at a point due to a number of point charges, using the equation E = KQ / r2 to determine the contribution to the field due to each charge. Restrict to three charges in a straight line.	3
Electric Circuits	Ohm's law	
	State Ohm's law in words: The potential difference across a conductor is directly proportional to the current in the conductor at constant temperature.	1
	Determine the relationship between current, potential difference and resistance at constant temperature using a simple circuit.	2
	State the difference between ohmic conductors and non-ohmic conductors and give an example of each.	1
	Solve problems using IVR= for series and parallel circuits (maximum four resistors).	3
	Power, energy	
	Define power as the rate at which work is done.	1
	Solve problems using P = tWΔ.	3
	Solve problems using P = VI ,P = I2R or P = RV2.	3
	Solve circuit problems involving the concepts of power and electrical energy.	3
	Deduce that the kilowatt-hour (kWh) refers to the use of 1 kilowatt of electricity for 1 hour.	2
	Calculate the cost of electricity usage given the power specifications of the appliances used, the duration and the cost of 1 kWh.	3
	Internal resistance, series and parallel networks	
	Solve problems involving current, voltage and resistance for circuits containing arrangements of resistors in series and in parallel (maximum four resistors).	3
	Explain the term internal resistance.	2
	Solve circuit problems using ε = Vload + Vinternal resistance or ε =IRext+ Ir.	3
	Solve circuit problems, with internal resistance, involving series-parallel networks of resistors (maximum four resistors).	3

Coding of the Guidelines 2014 continued.

Electricity and magnetism		
Subtopic	Content, concepts and skills	CDL
Electro-dynamics	*Electrical machines (generators, motors)*	
	State the energy conversion in generators.	1
	Use the principle of electromagnetic induction to explain how a generator works.	2
	Explain the functions of the components of an AC and a DC generator.	2
	State examples of the uses of AC and DC generators.	1
	State the energy conversion in motors.	1
	Use the motor effect to explain how a motor works.	2
	Explain the functions of the components of a motor.	2
	State examples of the use of motors.	1
	Alternating current	
	State the advantages of alternating current over direct current.	1
	Sketch graphs of voltage versus time and current versus time for an AC circuit.	3
	Define the term rms for an alternating voltage or an alternating current. The rms value of AC is the DC potential difference/current which dissipates the same amount of energy as AC.	1
	Solve problems using 2IImaxrms=, 2VVmaxrms=.	3
	Solve problems using Pave = IrmsVrms = ½ ImaxVmax (for a purely resistive circuit), Pave = I2rmsR and Pave = RV2rms	3

Optical phenomena		
Subtopic	Content, concepts and skills	CDL
Photo-electric effect	*Photo-electric effect*	
	Describe the photoelectric effect as the process whereby electrons are ejected from a metal surface when light of suitable frequency is incident on that surface.	2
	State the significance of the photoelectric effect.	1
	Define threshold frequency, fo, as the minimum frequency of light needed to emit electrons from a certain metal surface.	1
	Define work function, Wo, as the minimum energy that an electron in the metal needs to be emitted from the metal surface.	1
	Perform calculations using the photoelectric equation E =Wo+ Kmax, where E = hf and Wo= hfo and Kmax = ½mv2max	3
	Explain the effect of intensity and frequency on the photoelectric effect.	2

Coding of the Guidelines 2014 continued.

Optical phenomena		
Sub Topic	Content, concepts and skills	CDL
Emission and absorption spectra	*Emission and absorption spectra*	
	Explain the formation of atomic spectra by referring to energy transition.	2
	Explain the difference between atomic absorption spectra and atomic emission spectra.	
	An atomic absorption spectrum is formed when certain frequencies of electromagnetic radiation that passes through a medium, e.g. a cold gas, is absorbed.	2
	An atomic emission spectrum is formed when certain frequencies of electromagnetic radiation are emitted due to an atom's electrons making a transition from a high-energy state to a lower energy state.	2

MECHANICS		
Sub Topic	Content, Concepts and Skills	CDL
Newton's laws and application of Newton's laws	*Different kinds of forces: weight, normal force, frictional force, applied force (push, pull), tension (strings or cables)*	
	Define *normal force*, N, as the force or the component of a force which a surface exerts on an object with which it is in contact, and which is perpendicular to the surface.	1
	Define *frictional force*, f, as the force that opposes the motion of an object and which acts parallel to the surface.	1
	Define *static frictional force*, fs, as a force that opposes the tendency of motion of a stationary object relative to a surface.	1
	Define *kinetic frictional forc*e, fk, as the force that opposes the motion of a moving object relative to a surface.	1
	Know that a frictional force:	
	is proportional to the normal force	1
	is independent of the area of contact	1
	is independent of the velocity of motion	1
	Solve problems using fmaxs = μsN where fmaxs is the maximum static frictional force and μs is the coefficient of static friction	
	if a force, F, applied to a body parallel to the surface does not cause the object to move, F is equal in magnitude to the static frictional force.	3
	if the static frictional force is a maximum (fmaxs) just before the object starts to move across the surface.	3
	if the applied force exceeds fmaxs, a resultant/net force accelerates the object.	3
	Solve problems using fk = μkN, where fk is the kinetic frictional force and μk the coefficient of kinetic friction.	3
	Force diagrams, free-body diagrams	
	Draw force diagrams.	3
	Draw free-body diagrams. (This is a diagram that shows the relative magnitudes and directions of forces acting on a resultant/net force acts on it.	3
	Resolve a two-dimensional force (such as the weight of an object on an inclined plane) into its parallel (x) and perpendicular (y) components.	3
	Determine the resultant/net force of two or more forces.	3
	Newton's first, second and third laws of motion	
	State Newton's first law of motion: A body will remain in its state of rest or motion at constant velocity unless a non-zero resultant/net force acts on it.	1

Coding of the Guidelines 2015 continued.

MECHANICS		
Sub Topic	Content, Concepts and Skills	CDL
	Discuss why it is important to wear seatbelts using Newton's first law.	2
Newton's laws and application of Newton's laws	State Newton's second law of motion: When a resultant/net force acts on an object, the object will accelerate in the direction of the force at an acceleration directly proportional to the force and inversely proportional to the mass of the object.	1
	Draw force diagrams and free-body diagrams for objects that are in equilibrium or accelerating	3
	Apply Newton's laws of motion to a variety of equilibrium and non-equilibrium problems including:	
	A single object:	
	Moving on a horizontal plane with or without friction	3
	Moving on an inclined plane with or without friction	3
	Moving in the vertical plane (lifts, rockets, etc.)	3
	Two-body systems (joined by a light inextensible string):	
	Both on a flat horizontal plane with or without friction	3
	One on a horizontal plane with or without friction, and a second hanging vertically from a string over a frictionless pulley	3
	Both on an inclined plane with or without friction	3
	Both hanging vertically from a string over a frictionless pulley	3
	State Newton's third law of motion: When one body exerts a force on a second body, the second body exerts a force of equal magnitude in the opposite direction on the first body.	1
	Identify action-reaction pairs.	2
	List the properties of action-reaction pairs.	1
	Newton's Law of Universal Gravitation	
	State Newton's Law of Universal Gravitation: Each body in the universe attracts every other body with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centres.	1
	Solve problems using F=Gm1m1/r2.	3
	Calculate acceleration due to gravity on a planet using g = Gm/r2	3
	Describe weight as the gravitational force the Earth exerts on any object on or near its surface.	2
	Calculate weight using the expression w = mg.	3
	Calculate the weight of an object on other planets with different values of gravitational acceleration.	3
	Distinguish between mass and weight.	2

Coding of the Guidelines 2015 continued.

MECHANICS		
Sub Topic	Content, Concepts and Skills	CDL
Momentum and Impulse	Explain weightlessness.	2
	Define momentum as the product of an object's mass and its velocity.	1
	Describe the linear momentum of an object as a vector quantity with the same direction as the velocity of the object.	2
	Calculate the momentum of a moving object using p = mv.	3
	Describe the vector nature of momentum and illustrate it with some simple examples.	2
	Draw vector diagrams to illustrate the relationship between the initial momentum, the final momentum and the change in momentum for each of the above examples.	3
	Newton's second law of motion in terms of momentum	
	State Newton's second law of motion in terms of momentum: The resultant/net force acting on an object is equal to the rate of change of momentum of the object in the direction of the resultant/net force.	1
	Express Newton's second law of motion in symbols: Fnet= $\Delta p/\Delta t$.	1
	Calculate the change in momentum when a resultant/net force acts on an object and its velocity:	
	Increases in the direction of motion, e.g. 2nd stage rocket engine fires	3
	Decreases, e.g. brakes are applied	3
	Reverses its direction of motion, e.g. a soccer ball kicked back in the direction it came from	3
	Define impulse as the product of the resultant/net force acting on an object and the time the resultant/net force acts on the object.	1
	Deduce the impulse-momentum theorem: FnetΔt = mΔv.	2
	Use the impulse-momentum theorem to calculate the force exerted, the time for which the force is applied and the change in momentum for a variety of situations involving the motion of an object in one dimension.	3
	Explain how the concept of impulse applies to safety considerations in everyday life, e.g. airbags, seatbelts and arrestor beds.	2
	Conservation of momentum and elastic and inelastic collisions	
	Explain what is meant by a closed/an isolated system (in Physics), i.e. a system on which the resultant/net external force is zero. A closed/an isolated system excludes external forces that originate outside the colliding bodies, e.g. friction. Only internal forces, e.g. contact forces between the colliding objects, are considered.	2
	State the principle of conservation of linear momentum: The total linear momentum of a closed system remains constant (is conserved).	1

Coding of the Guidelines 2015 continued.

	MECHANICS	
Sub Topic	Content, Concepts and Skills	CDL
Momentum and Impulse	Apply the conservation of momentum to the collision of two objects moving in one dimension (along a straight line) with the aid of an appropriate sign convention.	3
	Distinguish between elastic collisions and inelastic collisions by calculation.	2
Vertical Projectile Motion in One Dimension (1D)	*Vertical Projectile Motion in One Dimension (1D)*	
	Explain what is meant by a projectile, i.e. an object upon which the only force acting is the force of gravity.	2
	Use equations of motion to determine the position, velocity and displacement of a projectile at any given time.	3
	Sketch position versus time (x vs. t), velocity versus time (v vs. t) and acceleration versus time (a vs. t) graphs for:	
	A free-falling object	
	An object thrown vertically upwards	3
	An object thrown vertically downwards	3
	Bouncing objects (restricted to balls)	3
	For a given x vs. t, v vs. t or a vs. t graph, determine:	
	Position	2
	Displacement	2
	Velocity or acceleration at any time t	2
	For a given x vs. t, v vs. t or a vs. t graph, describe the motion of the object:	
	Bouncing	2
	Thrown vertically upwards	2
	Thrown vertically downward	2
Work, Energy and Power	*Work*	
	Define the work done on an object by a constant force F as FxΔcosθ, where F is the magnitude of the force, xΔ the magnitude of the displacement and θ the angle between the force and the displacement. (Work is done by a force on an object – the use of 'work is done against a force', e.g. work done against friction, should be avoided.)	1
	Draw a force diagram and free-body diagrams.	3
	Calculate the net/total work done on an object.	3
	Distinguish between positive net/total work done and negative net/total work done on the system.	2

Coding of the Guidelines 2015 continued.

MECHANICS		
Sub Topic	Content, Concepts and Skills	CDL
Work, Energy and Power	*Work-energy theorem*	
	State the work-energy theorem: The net/total work done on an object is equal to the change in the object's kinetic energy OR the work done on an object by a resultant/net force is equal to the change in the object's kinetic energy. $W_{net} = \Delta K = K_f - K_i$.	1
	Apply the work-energy theorem to objects on horizontal, vertical and inclined planes (for both frictionless and rough surfaces).	3
	Conservation of energy with non-conservative forces present	
	Define a conservative force as a force for which the work done in moving an object between two points is independent of the path taken. Examples are gravitational force, the elastic force in a spring and electrostatic forces (Coulomb forces)	1
	Define a non-conservative force as a force for which the work done in moving an object between two points depends on the path taken. Examples are frictional force, air resistance, tension in a chord, etc.	1
	State the principle of conservation of mechanical energy: The total mechanical energy (sum of gravitational potential energy and kinetic energy) in an isolated system remains constant. (A system is isolated when the resultant/net external force acting on the system is zero.)	1
	Solve conservation of energy problems using the equation: $W_{nc} = \Delta E_k + \Delta E_p$	3
	Use the relationship above to show that in the absence of non-conservative forces, mechanical energy is conserved.	3
	Power	
	Define power as the rate at which work is done, or energy is expended. $P = W/\Delta t$	1
	Calculate the power involved when work is done.	3
	Perform calculations using $P_{ave} = Fv_{ave}$ when an object moves at a constant speed along a rough horizontal surface or a rough inclined plane.	3
	Calculate the power output for a pump lifting a mass (e.g. lifting water through a height at constant speed)	3

Coding of the Guidelines 2015 continued.

WAVES, SOUND & LIGHT		
Sub Topic	Content, Concepts and Skills	CDL
Doppler Effect	*Doppler effect*	
	With sound and ultrasound	
	State the Doppler effect as the change in frequency (or pitch) of the sound detected by a listener because the sound source and the listener have different velocities relative to the medium of sound propagation.	1
	Explain (using appropriate illustrations) the change in pitch observed when a source moves toward or away from a listener.	2
	Solve problems using the equation fl=(v±vl/v±vs)fs when EITHER the source or the listener is moving.	3
	State applications of the Doppler effect.	1
	With light – redshifts in the universe (evidence for the expanding universe)	
	Explain redshifts and blue shifts using the Doppler Effect.	2
	Use the Doppler effect to explain why we conclude that the universe is expanding.	2

ELECTRICITY & MAGNETISM		
Sub Topic	Content, Concepts and Skills	CDL
Electro-statics	State Coulomb's law: The magnitude of the electrostatic force exerted by one point charge (Q1) on another point charge (Q2) is directly proportional to the product of the magnitudes of the charges and inversely proportional to the square of the distance (r) between them.	1
	Solve problems using the equation F = kQ1Q2/R2 for charges:	
	in one dimension (1D) (restrict to three charges).	3
	in two dimensions (2D) – for three charges in a right-angled formation (limit to charges at the 'vertices of a right-angled triangle').	3
	Describe an electric field as a region of space in which an electric charge experiences a force. The direction of the electric field at a point is the direction that a positive test charge would move if placed at that point.	2
	Draw electric field patterns for the following configurations:	
	A single point charge	3
	Two point charges (one negative, one positive OR both positive OR both negative)	3
	A charged sphere	3
	Define the electric field at a point: The electric field at a point is the electrostatic force experienced per unit positive charge placed at that point. In symbols: E=F/q.	1

Coding of the Guidelines 2015 continued.

ELECTRICITY & MAGNETISM		
Sub Topic	Content, Concepts and Skills	CDL
Electro-statics	Solve problems using the equation E= F/q.	3
	Calculate the electric field at a point due to a number of point charges, using the equation E = kQ/r2 to determine the contribution to the field due to each charge. Restrict to three charges in a straight line.	3
Electric Circuits	State Ohm's law in words: The potential difference across a conductor is directly proportional to the current in the conductor at constant temperature.	1
	Determine the relationship between current, potential difference and resistance at constant temperature using a simple circuit.	2
	State the difference between ohmic conductors and non-ohmic conductors and give an example of each.	1
	Solve problems using R = V/I for series and parallel circuits (maximum four resistors).	3
	Power, energy	
	Define power as the rate at which work is done.	1
	Solve problems using P = W/Δt.	3
	Solve problems using P = VI ,P = I2R or P = V2/R.	3
	Solve circuit problems involving the concepts of power and electrical energy.	3
	Deduce that the kilowatt-hour (kWh) refers to the use of 1 kilowatt of electricity for 1 hour.	2
	Calculate the cost of electricity usage given the power specifications of the appliances used, the duration and the cost of 1 kWh.	3
	Internal resistance, series and parallel networks	
	Solve problems involving current, voltage and resistance for circuits containing arrangements of resistors in series and in parallel (maximum four resistors).	3
	Explain the term internal resistance.	2
	Solve circuit problems using ε = Vload + Vinternal resistance or ε =IRext+ Ir.	3
	Solve circuit problems, with internal resistance, involving series-parallel networks of resistors (maximum four resistors).	3
Electro dynamics	*Electrical machines (generators, motors)*	
	State the energy conversion in generators.	1
	Use the principle of electromagnetic induction to explain how a generator works.	2
	Explain the functions of the components of an AC and a DC generator.	2
	State examples of the uses of AC and DC generators.	1

Coding of the Guidelines 2015 continued.

ELECTRICITY & MAGNETISM		
Sub Topic	Content, Concepts and Skills	CDL
Electro dynamics	State the energy conversion in motors.	1
	Use the motor effect to explain how a motor works.	2
	Explain the functions of the components of a motor.	3
	State examples of the use of motors.	1
	State the advantages of alternating current over direct current.	1
	Sketch graphs of voltage versus time and current versus time for an AC circuit.	3
	Define the term rms for an alternating voltage or an alternating current. The rms value of AC is the DC potential difference/current which dissipates the same amount of energy as AC.	1
	Solve problems using Ims= Imax/√2, Vrms= Vmax/√2.	3
	Solve problems using Pave = IrmsVrms = ½ ImaxVmax (for a purely resistive circuit), Pave = Irms2R and Pave = Vrms2R	3

OPTICAL PHENOMENA & PROPERTIES OF MATTER		
Sub Topic	Content, Concepts and Skills	CDL
Photo-electric effect	Describe the photoelectric effect as the process whereby electrons are ejected from a metal surface when light of suitable frequency is incident on that surface.	2
	State the significance of the photoelectric effect.	1
	Define threshold frequency, fo, as the minimum frequency of light needed to emit electrons from a certain metal surface.	1
	Define work function, Wo, as the minimum energy that an electron in the metal needs to be emitted from the metal surface.	1
	Perform calculations using the photoelectric equation: E =Wo+ Kmax, where E = hf and Wo= hfo and Kmax = ½mv2max	3
	Explain the effect of intensity and frequency on the photoelectric effect.	2
Emission and Atomic Spectra	Explain the formation of atomic spectra by referring to energy transition.	2
	Explain the difference between atomic absorption spectra and atomic emission spectra.	
	An atomic absorption spectrum is formed when certain frequencies of electromagnetic radiation that passes through a medium, e.g. a cold gas, is absorbed.	2
	An atomic emission spectrum is formed when certain frequencies of electromagnetic radiation are emitted due to an atom's electrons making a transition from a high-energy state to a lower energy state.	2

MECHANICS		
Sub Topic	Content, Concepts and Skills	CDL
Newton's Laws and Application of Newton's Laws	Different kinds of forces: weight, normal force, frictional force, applied force (push, pull), tension (strings or cables)	
	Define normal force, N, as the force or the component of a force which a surface exerts on an object with which it is in contact, and which is perpendicular to the surface.	1
	Define frictional force, f, as the force that opposes the motion of an object and which acts parallel to the surface.	1
	Define static frictional force, fs, as the force that opposes the tendency of motion of a stationary object relative to a surface.	1
	Define kinetic frictional force, fk, as the force that opposes the motion of a moving object relative to a surface.	1
	Know that a frictional force:	
	Is proportional to the normal force	1
	Is independent of the area of contact	1
	Is independent of the velocity of motion	1
	Solve problems using $f_{smax}= \mu_s N$ where f_{smax} the maximum static frictional force and sμ is the coefficient of static friction.	
	If a force, F, applied to a body parallel to the surface does not cause the object to move, F is equal in magnitude to the static frictional force.	3
	The static frictional force is a maximum (maxsf) just before the object starts to move across the surface.	3
	If the applied force exceeds maxsf, a resultant/net force accelerates the object.	3
	Solve problems using $f_k = \mu_k N$, where f_k is the kinetic frictional force and μ_k the coefficient of kinetic friction.	3
	Force diagrams, free-body diagrams	
	Draw force diagrams.	3
	Draw free-body diagrams. (This is a diagram that shows the relative magnitudes and directions of forces acting on a body/particle that has been isolated from its surroundings)	3
	Resolve a two-dimensional force (such as the weight of an object on an inclined plane) into its parallel (x) and perpendicular (y) components.	3
	Determine the resultant/net force of two or more forces.	3
	Newton's first, second and third laws of motion	
	State Newton's first law of motion: A body will remain in its state of rest or motion at constant velocity unless a non-zero resultant/net force acts on it.	1
	Discuss why it is important to wear seatbelts using Newton's first law of motion.	2

Coding of the Guidelines 2016 continued.

MECHANICS		
Sub Topic	Content, Concepts and Skills	CDL
Newton's Laws and Application of Newton's Laws	State Newton's second law of motion: When a resultant/net force acts on an object, the object will accelerate in the direction of the force at acceleration directly proportional to the force and inversely proportional to the mass of the object.	1
	Draw force diagrams and free-body diagrams for objects that are in equilibrium or accelerating.	3
	Apply Newton's laws of motion to a variety of equilibrium and non-equilibrium problems including:	
	A single object:	
	Moving on a horizontal plane with or without friction	3
	Moving on an inclined plane with or without friction	3
	Moving in the vertical plane (lifts, rockets, etc.)	3
	Two-body systems (joined by a light inextensible string):	
	Both on a flat horizontal plane with or without friction	3
	One on a horizontal plane with or without friction, and a second hanging vertically from a string over a frictionless pulley	3
	Both on an inclined plane with or without friction	3
	Both hanging vertically from a string over a frictionless pulley	3
	State Newton's third law of motion: When one body exerts a force on a second body, the second body exerts a force of equal magnitude in the opposite direction on the first body.	1
	Identify action-reaction pairs.	2
	List the properties of action-reaction pairs.	1
	Newton's Law of Universal Gravitation	
	State Newton's Law of Universal Gravitation: Each body in the universe attracts every other body with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centres.	1
	Solve problems using F = GM1M2/r2	3
	Calculate acceleration due to gravity on a planet using g = GM/r2	3
	Describe weight as the gravitational force the Earth exerts on any object on or near its surface,	2
	Calculate weight using the expression w = mg.	3
	Calculate the weight of an object on other planets with different values of gravitational acceleration.	3
	Distinguish between mass and weight.	2
	Explain weightlessness.	2

Coding of the Guidelines 2016 continued.

MECHANICS		
Sub Topic	Content, Concepts and Skills	CDL
Momentum and Impulse	*Momentum*	
	Define momentum as the product of an object's mass and its velocity.	1
	Describe the linear momentum of an object as a vector quantity with the same direction as the velocity of the object.	2
	Calculate the momentum of a moving object using p = mv.	3
	Describe the vector nature of momentum and illustrate it with some simple examples.	3
	Draw vector diagrams to illustrate the relationship between the initial momentum, the final momentum and the change in momentum for each of the above examples.	3
	Newton's second law of motion in terms of momentum	
	State Newton's second law of motion in terms of momentum: The resultant/net force acting on an object is equal to the rate of change of momentum of the object in the direction of the resultant/net force.	1
	Express Newton's second law of motion in symbols: $F_{net} = \Delta p/\Delta t$	2
	Calculate the change in momentum when a resultant/net force acts on an object and its velocity:	
	Increases in the direction of motion, e.g. 2nd stage rocket engine fires	3
	Decreases, e.g. brakes are applied	3
	Reverses its direction of motion, e.g. a soccer ball kicked back in the direction it came from	3
	Impulse	
	Define impulse as the product of the resultant/net force acting on an object and the time the resultant/net force acts on the object.	1
	Deduce the impulse-momentum theorem: $F_{net}\Delta t = m\Delta v$	2
	Use the impulse-momentum theorem to calculate the force exerted, the time for which the force is applied and the change in momentum for a variety of situations involving the motion of an object in one dimension.	3
	Explain how the concept of impulse applies to safety considerations in everyday life, e.g. airbags, seatbelts and arrestor beds.	2
	Conservation of momentum and elastic and inelastic collisions	
	Explain what is meant by a closed/an isolated system (in Physics), i.e. a system on which the resultant/net external force is zero.	2
	A closed/an isolated system excludes external forces that originate outside the colliding bodies, e.g. friction. Only internal forces, e.g. contact forces between the colliding objects, are considered.	
	State the principle of conservation of linear momentum: The total linear momentum of a closed system remains constant (is conserved).	1

Coding of the Guidelines 2016 continued.

MECHANICS		
Sub Topic	Content, Concepts and Skills	CDL
Momentum and Impulse	Apply the conservation of momentum to the collision of two objects moving in one dimension (along a straight line) with the aid of an appropriate sign convention.	3
	Distinguish between elastic collisions and inelastic collisions by calculation.	2
Vertical Projectile Motion (1D)	*Vertical Projectile Motion (1D)*	
	Explain what is meant by a projectile, i.e. an object upon which the only force acting is the force of gravity.	2
	Use equations of motion to determine the position, velocity and displacement of a projectile at any given time.	3
	Sketch position versus time (x vs. t), velocity versus time (v vs. t) and acceleration versus time (a vs. t) graphs for:	
	A free-falling object	
	An object thrown vertically upwards	3
	An object thrown vertically downwards	3
	Bouncing objects (restricted to balls)	3
	For a given x vs. t, v vs. t or a vs. t graph, determine:	
	Position	3
	Displacement	3
	Velocity or acceleration at any time t	3
	For a given x vs. t, v vs. t or a vs. t graph, describe the motion of the object:	
	Bouncing	2
	Thrown vertically upwards	2
	Thrown vertically downward	2
Work, Energy & Power	*Work*	
	Define the work done on an object by a constant force F as Fx cosθΔ, where F is the magnitude of the force, xΔ the magnitude of the displacement and θ the angle between the force and the displacement. (Work is done by a force on an object – the use of 'work is done against a force', e.g. work done against friction, should be avoided.)	1
	Draw a force diagram and free-body diagrams.	3
	Calculate the net/total work done on an object.	3
	Distinguish between positive net/total work done and negative net/total work done on the system.	2

Coding of the Guidelines 2016 continued.

	MECHANICS	
Sub Topic	Content, Concepts and Skills	CDL
Work, Energy & Power	*Work-energy theorem*	
	State the work-energy theorem: The net/total work done on an object is equal to the change in the object's kinetic energy OR the work done on an object by a resultant/net force is equal to the change in the object's kinetic energy.	1
	in symbols: netfiW = K = K - KΔ	1
	Apply the work-energy theorem to objects on horizontal, vertical and inclined planes (for both frictionless and rough surfaces).	3
	Conservation of energy with non-conservative forces present	
	Define a conservative force as a force for which the work done in moving an object between two points is independent of the path taken. Examples are gravitational force, the elastic force in a spring and electrostatic forces (Coulomb forces).	1
	Define a non-conservative force as a force for which the work done in moving an object between two points depends on the path taken. Examples are frictional force, air resistance, tension in a chord, etc.	1
	State the principle of conservation of mechanical energy: The total mechanical energy (sum of gravitational potential energy and kinetic energy) in an isolated system remains constant. (A system is isolated when the resultant/net external force acting on the system is zero.)	1
	Solve conservation of energy problems using the equation: Wnc = ΔEk + Δep	3
	Use the relationship above to show that in the absence of non-conservative forces, mechanical energy is conserved.	3
	Power	
	Define power as the rate at which work is done, or energy is expended.	1
	In symbols: WP = tΔ	1
	Calculate the power involved when work is done.	3
	Perform calculations using Pave = Fv when an object moves at a constant speed along a rough horizontal surface or a rough inclined plane.	3
	Calculate the power output for a pump lifting a mass (e.g. lifting water through a height at constant speed.	3

Coding of the Guidelines 2016 continued.

WAVES, LIGHT & SOUND		
Sub Topic	Content, Concepts and Skills	CDL
Doppler effect	*With sound and ultrasound*	
	State the Doppler effect as the change in frequency (or pitch) of the sound detected by a listener because the sound source and the listener have different velocities relative to the medium of sound propagation.	1
	Explain (using appropriate illustrations) the change in pitch observed when a source moves toward or away from a listener.	2
	Solve problems using the equation fl = (V +- Vl) / (V +- Vs) * fs when either source or listener is moving	3
	State applications of the Doppler effect.	1
	With light – redshifts in the universe (evidence for the expanding universe)	
	Explain redshifts and blue shifts using the Doppler Effect.	2
	Use the Doppler effect to explain why we conclude that the universe is expanding.	2

ELECTRICITY & MAGNETISM		
Sub Topic	Content, Concepts and Skills	CDL
Electro-statics	*Coulomb's law*	
	State Coulomb's law: The magnitude of the electrostatic force exerted by one point charge (Q1) on another point charge (Q2) is directly proportional to the product of the magnitudes of the charges and inversely proportional to the square of the distance (r) between them:	1
	Solve problems using the equation F = kQ1Q2/r2 for charges in one dimension (1D)	3
	Solve problems using the equation F = kQ1Q2/r2 for charges in two dimensions (2D) – for three charges in a right-angled formation (limit to charges at the 'vertices of a right-angled triangle').	3
	Electric field	
	Describe an electric field as a region of space in which an electric charge experiences a force. The direction of the electric field at a point is the direction that a positive test charge would move if placed at that point.	2
	Draw electric field patterns for the following configurations:	
	A single point charge	3
	Two point charges (one negative, one positive OR both positive OR both negative)	3
	A charged sphere	3

Coding of the Guidelines 2016 continued.

ELECTRICITY & MAGNETISM		
Sub Topic	Content, Concepts and Skills	CDL
Electro-statics	Define the electric field at a point: The electric field at a point is the electrostatic force experienced per unit positive charge placed at that point.	1
	In symbols: E = F/q	1
	Solve problems using the equation E = F/q	3
	Calculate the electric field at a point due to a number of point charges, using the equation E = kQ/r2 to determine the contribution to the field due to each charge. Restrict to three charges in a straight line.	3
Electric Circuits	*Ohm's law*	
	State Ohm's law in words: The potential difference across a conductor is directly proportional to the current in the conductor at constant temperature.	1
	Determine the relationship between current, potential difference and resistance at constant temperature using a simple circuit.	2
	State the difference between ohmic conductors and non-ohmic conductors and give an example of each.	1
	Solve problems using VR = I for series and parallel circuits (maximum four resistors).	3
	Power & energy	
	Define power as the rate at which work is done.	1
	Solve problems using P = W/Δt	3
	Solve problems using P = VI, P = I2R or P =V/R2	3
	Solve circuit problems involving the concepts of power and electrical energy.	3
	Deduce that the kilowatt-hour (kWh) refers to the use of 1 kilowatt of electricity for 1 hour.	2
	Calculate the cost of electricity usage given the power specifications of the appliances used the duration and the cost of 1 kWh.	3
	Internal resistance, series and parallel networks	
	Solve problems involving current, voltage and resistance for circuits containing arrangements of resistors in series and in parallel (maximum four resistors).	3
	Explain the term internal resistance.	2
	Solve circuit problems using ε = IR + Ir	3
	Solve circuit problems, with internal resistance, involving series-parallel networks of resistors (maximum four resistors).	3

Coding of the Guidelines 2016 continued.

ELECTRICITY & MAGNETISM		
Sub Topic	Content, Concepts and Skills	CDL
Electro-dynamics	*Electrical machines (generators, motors)*	
	State the energy conversion in generators.	1
	Use the principle of electromagnetic induction to explain how a generator works.	2
	Explain the functions of the components of an AC and a DC generator.	2
	State examples of the uses of AC and DC generators.	1
	State the energy conversion in motors.	1
	Use the motor effect to explain how a motor works.	2
	Explain the functions of the components of a motor.	2
	State examples of the use of motors.	1
	Alternating current	
	State the advantages of alternating current over direct current.	1
	Sketch graphs of voltage versus time and current versus time for an AC circuit.	3
	Define the term rms for an alternating voltage or an alternating current. The rms value of AC is the DC potential difference/current which dissipates the same amount of energy as AC.	1
	Solve problem using I and V rms equations	3
	Solve problem using Pave rms equations	3

PROPERTIES OF MATTER		
Sub Topic	Content, Concepts and Skills	CDL
Photo-electric effect	Describe the photoelectric effect as the process whereby electrons are ejected from a metal surface when light of suitable frequency is incident on that surface.	2
	State the significance of the photoelectric effect.	1
	Define threshold frequency, fo, as the minimum frequency of light needed to emit electrons from a certain metal surface.	1
	Define work function, Wo, as the minimum energy that an electron in the metal needs to be emitted from the metal surface.	1
	Perform calculations using the photo-electric equation: 2omaxoomaxmax1E = W + K, where E = hf and W = hf and K = mv2	3
	Explain the effect of intensity and frequency on the photoelectric effect.	2
Atomic Spectra	Explain the formation of atomic spectra by referring to energy transition.	2
	Explain the difference between atomic absorption spectra and atomic emission spectra.	2

MECHANICS		
Sub Topic	Content, Concepts and Skills	CDL
Newton's Laws and Application of Newton's Laws	*Different kinds of forces: weight, normal force, frictional force, applied force (push, pull), tension (strings or cables)*	
	Define normal force, N.	1
	Define frictional force, *f*.	1
	Force diagrams, free-body diagrams	
	Draw force diagrams.	3
	Draw free-body diagrams.	3
	Resolve two-dimensional forces (such as the weight of an object with respect to the inclined plane) into its parallel (x) and perpendicular (y) components.	3
	Determine the resultant or net force of two or more forces.	3
	Newton's first, second and third laws	
	State Newton's first law: A body will remain in its state of motion (at rest or moving at constant velocity) until a net force acts on it.	1
	Discuss why it is important to wear seatbelts using Newton's first law.	2
	State Newton's second law: When a net force acts on an object, the object will accelerate in the direction of the force, and the acceleration is directly proportional to the force and inversely proportional to the mass of the object.	1
	Draw force diagrams and free-body diagrams for objects that are in equilibrium or accelerating.	3
	Apply Newton's laws to a variety of problems including:	
	A single object:	
	- Moving on a horizontal plane with or without friction	3
	- Moving on an inclined plane with and without friction	3
	- Moving in the vertical plane (lifts, rockets, etc.)	3
	Two-body systems (joined by a light inextensible string):	
	- Both on a flat horizontal plane with and without friction	3
	- One on a horizontal plane with and without friction, and a second hanging vertically from a string over a frictionless pulley	3
	- Both on an inclined plane with or without friction	3
	- Both hanging vertically from a string over a frictionless pulley	3
	State Newton's third law: When one body exerts a force on a second body, the second body exerts a force of equal magnitude in the opposite direction on the first body.	1

Coding of the Guidelines 2017 continued.

MECHANICS		
Sub Topic	Content, Concepts and Skills	CDL
Newton's Laws and Application of Newton's Laws	Identify action-reaction pairs.	1
	List the properties of action-reaction pairs.	1
	Newton's Law of Universal Gravitation	
	State Newton's Law of Universal Gravitation: Each body in the universe attracts every other body with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centres.	1
	Solve problems using F = Gm1m2/r2	3
	Describe weight as the gravitational force the Earth exerts on any object on or near its surface	2
	Calculate weight using the expression w = mg.	3
	Calculate the weight of an object on other planets with different values of gravitational acceleration.	3
	Distinguish between mass and weight.	2
	Explain weightlessness.	2
Momentum and Impulse	*Momentum*	
	Define momentum as the product of an object's mass and its velocity.	1
	Describe linear momentum as a vector quantity with the same direction as the velocity of the object.	2
	Calculate the momentum of a moving object using p = mv.	3
	Describe the vector nature of momentum and illustrate it with some simple examples.	2
	Draw vector diagrams to illustrate the relationship between the initial momentum, the final momentum and the change in momentum for each of the cases above.	3
	Newton's second law in terms of momentum	
	State Newton's second law of motion in terms of momentum: The net (or resultant) force acting on an object is equal to the rate of change of momentum of the object in the direction of the net force.	1
	Express Newton's second law in symbols: Fnet= $\Delta p/\Delta t$	2
	Calculate the change in momentum when a resultant force acts on an object and its velocity:	
	Increases in the direction of motion, e.g. 2nd stage rocket engine fires	3
	Decreases, e.g. brakes are applied	3
	Reverses its direction of motion, e.g. a soccer ball kicked back in the direction it came from.	3

Coding of the Guidelines 2017 continued.

MECHANICS		
Sub Topic	Content, Concepts and Skills	CDL
Momentum and Impulse	*Impulse*	
	Define impulse as the product of the net force acting on an object and the time the net force acts on the object.	1
	Deduce the impulse-momentum theorem: $F_{net}\Delta t = m\Delta v$	2
	Use the impulse-momentum theorem to calculate the force exerted, the time for which the force is applied and the change in momentum for a variety of situations involving the motion of an object in one dimension.	3
	Explain how the concept of impulse applies to safety considerations in everyday life, e.g. airbags, seatbelts and arrestor beds.	2
	Conservation of momentum and elastic and inelastic collisions	
	Explain what is meant by:	
	An isolated system (in Physics): An isolated system is one on which the net external force acting on the system is zero.	2
	Internal and external forces	2
	State the principle of conservation of linear momentum: The total linear momentum of an isolated system remains constant.	1
	Apply the conservation of momentum to the collision of two objects moving in one dimension (along a straight line) with the aid of an appropriate sign convention.	3
	Distinguish between elastic collisions and inelastic collisions by calculation.	2
Vertical Projectile Motion in One Dimension (1D)	*Vertical Projectile Motion in One Dimension (1D)*	
	Explain what is meant by a projectile, i.e. an object upon which the only force acting is the force of gravity.	2
	Use equations of motion to determine the position, velocity and displacement of a projectile at any given time.	3
	Sketch position versus time (x vs. t), velocity versus time (v vs. t) and acceleration versus time (a vs. t) graphs for:	
	A free-falling object	3
	An object thrown vertically upwards	3
	An object thrown vertically downwards	3
	Bouncing objects (restricted to balls)	3
	For a given x vs. t, v vs. t or a vs. t graph, determine:	
	Position	2
	Displacement	2
	Velocity or acceleration at any time t	2

Coding of the Guidelines 2017 continued.

MECHANICS		
Sub Topic	Content, Concepts and Skills	CDL
Vertical Projectile Motion in One Dimension	*For a given x vs. t, v vs. t or a vs. t graph, describe the motion of the object:*	
	Bouncing	2
	Thrown vertically upwards	2
	Thrown vertically downward	2
Work, Energy and Power	*Work*	
	Define the work done on an object by a constant force F as F = $\Delta x \cos \theta$, where F is the magnitude of the force, Δx the magnitude of the displacement and θ the angle between the force and the displacement. (Work is done by a force – the use of the term 'work is done against a force', e.g. work done against friction, must be avoided.)	1
	Draw a force diagram and free-body diagrams.	3
	Calculate the net work done on an object.	3
	Distinguish between positive net work done and negative net work done on the system.	2
	Work-energy theorem	
	State the work-energy theorem: The work done on an object by a net force is equal to the change in the object's kinetic energy: Wnet = Δ K = Kf - Ki	1
	Apply the work-energy theorem to objects on horizontal, vertical and inclined planes (for both frictionless and rough surfaces).	3
	Conservation of energy with non-conservative forces present	
	Define a conservative force as a force for which the work done in moving an object between two points is independent of the path taken. Examples are gravitational force, the elastic force in a spring and Coulombic force.	1
	Define a non-conservative force as a force for which the work done in moving an object between two points depends on the path taken. Examples are frictional force, air resistance, tension in a chord, etc.	1
	State the principle of conservation of mechanical energy: The total mechanical energy (sum of gravitational potential energy and kinetic energy) in an isolated system remains constant. A system is isolated when the net external force (excluding the gravitational force) acting on the system is zero.)	1
	Solve conservation of energy problems using the equation: Wnc = ΔEk + ΔEp	3
	Use the relationship above to show that in the absence of non-conservative forces, mechanical energy is conserved.	3

Coding of the Guidelines 2017 continued.

MECHANICS		
Sub Topic	Content, Concepts and Skills	CDL
Work, Energy and Power	*Power*	
	Define *power* as the rate at which work is done, or energy is expended. In symbols: $P = W/\Delta t$	1
	Calculate the power involved when work is done.	3
	Perform calculations using Pave= Fxvave when an object moves at a constant speed along a rough horizontal surface or a rough inclined plane.	3
	Calculate the power output for a pump lifting a mass (e.g. lifting water through a height at constant speed).	3

WAVES, LIGHT AND SOUND		
Sub Topic	Content, Concepts and Skills	CDL
Doppler Effect (relative motion between source and observer)	*With sound and ultrasound*	
	State the Doppler effect as the change in frequency (or pitch) of the sound detected by a listener, because the sound source and the listener have different velocities relative to the medium of sound propagation.	1
	Explain (using appropriate illustrations) the change in pitch observed when a source moves toward or away from a listener.	2
	Solve problems using the equation $f_l = (v \pm v_l)/(v \pm vs)f_s$ when EITHER the source OR the listener is moving.	3
	State applications of the Doppler effect.	1
	With light – redshifts in the universe (evidence for the expanding universe)	
	Explain redshifts.	2
	Use the Doppler effect to explain why we conclude that the universe is expanding.	2

	ELECTRICITY & MAGNETISM	
Sub Topic	Content, Concepts and Skills	CDL
Electro-statics	*Coulomb's law*	
	State Coulomb's law: The magnitude of the electrostatic force exerted by one point charge (Q1) on another point charge (Q2) is directly proportional to the magnitudes of the charges and inversely proportional to the square of the distance (r) between them.	1

Coding of the Guidelines 2017 continued.

ELECTRICITY & MAGNETISM		
Sub Topic	Content, Concepts and Skills	CDL
Electro-statics	Solve problems using the equation $F = kQ1Q2/r2$ (restrict to three charges).	
	for charges in one dimension (1D)	3
	for charges in two dimensions (2D) – for three charges in a right-angled formation (limit to charges at the 'vertices of a right-angled triangle').	3
	Describe an electric field as a region of space in which an electric charge experiences a force. The direction of the electric field at a point is the direction that a positive test charge would move if placed at that point.	2
	Draw electric field patterns for:	
	A single point charge	3
	Two point charges	3
	A charged sphere	3
	Define the electric field at a point: The electric field at a point is the electrostatic force experienced per unit positive charge placed at that point. In symbols: $E = F / q$	1
	Solve problems using the equation $E = F / q$.	3
	Calculate the electric field at a point due to a number of point charges, using the equation $E = kQ / r2$ to determine the contribution to the field due to each charge. Restrict to three charges in a straight line.	3
Electric Circuits	*Ohm's law*	
	State Ohm's law in words: The potential difference across a conductor is directly proportional to the current in the conductor at constant temperature.	1
	Determine the relationship between current, voltage and resistance at constant temperature using a simple circuit.	2
	State the difference between ohmic conductors and non-ohmic conductors and give an example of each.	1
	Solve problems using $R = V / I$ for series and parallel circuits (maximum four resistors).	3
	Define power as the rate at which work is done.	1
	Solve problems using $P = W / \Delta t$.	3
	Solve problems using $P = VI$, $P = I2R$ or $P = V/ R$	3
	Solve circuit problems involving the concepts of power and electrical energy.	3
	Deduce that the kilowatt-hour (kWh) refers to the use of 1 kilowatt of electricity for 1 hour.	2

Coding of the Guidelines 2017 continued.

ELECTRICITY & MAGNETISM		
Sub Topic	Content, Concepts and Skills	CDL
	Calculate the cost of electricity usage given the power specifications of the appliances used as well as the duration if the cost of 1 kWh is given.	3
	Internal resistance, series and parallel networks	
	Solve problems involving current, voltage and resistance for circuits containing arrangements of resistors in series and in parallel (maximum four resistors).	3
	Explain the term internal resistance.	2
	Solve circuit problems using ε = Vload + Vinternal resistance or ε =IRext+ Ir.	3
	Solve circuit problems, with internal resistance, involving series-parallel networks of resistors (maximum four resistors).	3
Electro-dynamics	*Electrical machines (generators, motors)*	
	State the energy conversion in generators.	1
	Use the principle of electromagnetic induction to explain how a generator works.	2
	Explain the functions of the components of an AC and a DC generator.	2
	State examples of the uses of AC and DC generators.	1
	State the energy conversion in motors.	1
	Use the motor effect to explain how a motor works.	2
	Explain the functions of the components of a motor.	2
	State examples of the use of motors.	1
	Alternating current	
	State the advantages of alternating current over direct current.	1
	Sketch graphs of voltage vs. time and current vs. time for an AC circuit.	3
	Define the term rms for an alternating voltage/current. The rms value of AC is the direct current/voltage, which dissipates the same amount of energy as AC.	3
	Solve problems using Irms	3
	Solve problems using Pave = IrmsVrms = ½ ImaxVmax (for a purely resistive circuit),	3

Coding of the Guidelines 2017 continued.

OPTICAL PHENOMENA AND PROPERTIES OF MATERIALS		
Sub Topic	Content, Concepts and Skills	CDL
Photo-electric effect	*Photo-electric effect*	
	Describe the photoelectric effect as the process whereby electrons are ejected from a metal surface when light of suitable frequency is incident on that surface.	2
	State the significance of the photoelectric effect.	1
	Define threshold frequency, fo, as the minimum frequency of light needed to emit electrons from a certain metal surface.	1
	Define work function, Wo: The work function of a metal is the minimum energy that an electron in the metal needs to be emitted from the metal surface.	1
	Perform calculations using the photoelectric equation: E = W o+ Ekmax, where E = hf and Wo= hfo and Ekmax = ½ m(vmax)2	3
	Explain the effect of intensity and frequency on the photoelectric effect.	2
Emission and absorption spectra	*Emission and absorption spectra*	
	Explain the formation of atomic spectra by referring to energy transition.	2
	Explain the difference between atomic absorption and emission spectra.	2

Appendix H. Coding of P1 November 2014.

Q	MARKS	PST	CDL
1.1	2	1	1
1.2	2	1	2
1.3	2	1	2
1.4	2	1	2
1.5	2	1	2
1.6	2	2	2
1.7	2	3	2
1.8	2	3	2
1.9	2	3	2
1.10	2	4	2
2.1	2	1	1
2.2	3	1	2
2.3	6	1	3
2.4	1	1	1
3.1	2	1	2
3.2	4	1	3
3.3	7	1	3
3.4	4	1	2
4.1	3	1	3
4.2	2	1	1
4.3	3	1	3
4.4	1	1	2
4.5	3	1	2
5.1.1	2	1	1
5.1.2	1	1	2
5.1.3	6	1	3
5.2.1	3	1	3
5.2.2	6	1	3
6.1.1	2	2	1
6.1.2	2	2	2
6.1.3	5	2	3
6.2	2	2	2
7.1	1	3	2
7.2	2	3	3
7.3	3	3	2

Q	MARKS	PST	CDL
7.4	2	3	2
7.5	6	3	3
7.6	2	3	1
7.7	3	3	3
8.1.1	1	3	2
8.1.2	3	3	3
8.1.3	1	3	2
8.1.4	3	3	2
8.2.1	3	3	3
8.2.2	3	3	3
8.2.3	5	3	3
8.2.4	1	3	2
8.2.5	2	3	2
9.1	1	3	1
9.2	1	3	2
9.3	1	3	1
9.4.1	2	3	1
9.4.2	3	3	3
10.1	2	4	1
10.2	5	4	3
10.3	1	4	1
10.4	3	4	2

Appendix I. Coding of P1 March 2015.

Q	MARKS	PST	CDL
1.1	2	1	2
1.2	2	1	3
1.3	2	1	2
1.4	2	1	2
1.5	2	1	2
1.6	2	2	1
1.7	2	3	2
1.8	2	3	2
1.9	2	3	2
1.10	2	4	1
2.1	2	1	1
2.2	5	1	2
2.3.1	3	1	3
2.3.2	6	1	3
3.1	1	1	1
3.2.1	4	1	3
3.2.2	5	1	3
3.3	3	1	2
4.1	5	1	3
4.2	2	1	1
4.3	4	1	3
5.1	4	1	3
5.2	2	1	2
5.3	2	1	2
5.4	7	1	3
6.1.1	2	2	3
6.1.2	6	2	3
6.2	2	2	2
6.3	2	2	2
7.1	2	3	1
7.2.1	4	3	3
7.2.2	3	3	3
7.3.1	1	3	2
7.3.2	8	3	3
8.1.1	2	3	1
8.1.2	8	3	3
8.2.1	3	3	3
8.2.2	7	3	3
8.2.3	2	3	2
9.1.1	5	3	3
9.1.2	3	3	3
9.2	1	3	1
10.1	2	4	1
10.2	4	4	3
10.3	4	4	3
10.4.1	1	4	2
10.4.2	1	4	1
10.4.3	2	4	2

Appendix J. Coding of P1 November 2015.

Q	MARKS	PST	CDL
1.1	2	1	2
1.2	2	1	3
1.3	2	1	2
1.4	2	1	2
1.5	2	1	2
1.6	2	2	1
1.7	2	1	2
1.8	2	3	2
1.9	2	3	2
1.10	2	4	1
2.1.1	2	1	1
2.1.2	3	1	3
2.1.3	5	1	3
2.1.4	5	1	3
2.2	4	1	3
3.1	4	1	3
3.2	3	1	3
3.3	6	1	3
4.1	4	1	3
4.2	5	1	3
4.3	1	1	2
5.1	3	1	3
5.2	4	1	3
5.3	2	1	1
5.4	6	1	3
6.1.1	1	2	1
6.1.2	2	2	1
6.1.3	2	2	2
6.1.4	5	2	3
6.2	1	2	2
7.1	3	3	3
7.2	3	3	3
7.3	2	3	1
7.4	5	3	3
8.1	6	3	3

Q	MARKS	PST	CDL
8.2	4	3	3
8.3	1	3	2
9.1	2	3	1
9.2	4	3	3
9.3	5	3	3
9.4	3	3	3
10.1.1	2	3	2
10.1.2	1	3	1
10.1.3	1	3	1
10.2.1	4	3	3
10.2.2	3	3	3
11.1	2	4	2
11.2	3	4	3
11.3.1	4	4	3
11.3.2	4	4	3

Appendix K. Coding of P1 March 2016.

Q	MARKS	PST	CDL
1.1	2	1	2
1.2	2	1	3
1.3	2	1	2
1.4	2	1	3
1.5	2	1	3
1.6	2	2	2
1.7	2	3	2
1.8	2	3	3
1.9	2	3	2
1.10	2	4	3
2.1.1	5	1	3
2.1.2	4	1	3
2.1.3	1	1	3
2.2.1	2	1	1
2.2.2	6	1	3
3.1.1	3	1	3
3.1.2	3	1	3
3.1.3	5	1	3
3.2	5	1	3
4.1	2	1	1
4.2.1	4	1	3
4.2.2	4	1	3
4.3	1	1	2
5.1	1	1	2
5.2	2	1	1
5.3	4	1	3
5.4	4	1	3
5.5	4	1	3
6.1	3	2	3
6.2.1	1	2	2
6.2.2	6	2	3
7.1	1	1	2
7.2	2	3	1
7.3.1	3	3	3
7.3.2	5	3	3

Q	MARKS	PST	CDL
8.1	4	3	3
8.2	6	3	3
9.1.1	3	3	3
9.1.2	4	3	3
9.1.3	5	3	3
9.2	3	3	3
10.1.1	1	3	2
10.1.2	1	3	2
10.2.1	5	3	3
10.2.2	5	3	3
11.1	2	4	1
11.2	1	4	1
11.3	2	4	1
11.4	5	4	3
11.5	2	4	3

Appendix L. Coding of P1 November 2016.

Q	MARKS	PST	CDL
1.1	2	1	1
1.2	2	1	3
1.3	2	1	1
1.4	2	1	2
1.5	2	1	3
1.6	2	2	1
1.7	2	3	2
1.8	2	3	2
1.9	2	3	2
1.10	2	4	2
2.1	2	1	1
2.2	3	1	3
2.3	5	1	3
2.4.1	3	1	3
2.4.2	5	1	3
3.1	2	1	1
3.2.1	4	1	3
3.2.2	3	1	3
3.3	2	1	3
4.1	1	1	2
4.2.1	3	1	3
4.2.2	5	1	3
4.2.3	4	1	3
5.1.1	3	1	3
5.1.2	4	1	3
5.2	2	1	1
5.3	4	1	3
6.1.1	2	2	1
6.1.2	3	2	3
6.1.3	5	2	3
6.1.4	1	2	3
6.2	2	2	2
7.1.1	2	3	1
7.1.2	1	3	1
7.1.3	1	3	2
7.1.4	6	3	3
7.2.1	2	3	2
7.2.2	5	3	3
8.1	2	3	1
8.2	1	3	1
8.3	1	3	1
8.4	3	3	3
8.5	2	3	3
8.6	4	3	3
8.2.1	3	3	3
8.2.2	5	3	3
9.1.1	2	3	2
9.1.2	2	3	3
9.2.1	3	3	3
9.2.2	4	3	3
10.1.1	3	4	1
10.1.2	2	4	3
10.1.3	1	4	3
10.1.4	1	4	2
10.2.1	5	4	3
10.2.2	1	4	2

Appendix M. Coding of P1 March 2017.

Q	MARKS	PST	CDL
1.1	2	1	2
1.2	2	1	2
1.3	2	1	3
1.4	2	1	3
1.5	2	1	3
1.6	2	2	2
1.7	2	3	2
1.8	2	3	2
1.9	2	3	1
1.10	2	4	1
2.1	1	1	1
2.2	3	1	3
2.3.1	3	1	3
2.3.2	3	1	3
2.3.3	5	1	3
3.1	2	1	1
3.2	2	1	2
3.3	4	1	3
3.4	6	1	3
4.1	2	1	1
4.2.1	3	1	3
4.2.2	5	1	3
4.3	2	1	1
5.1	2	1	1
5.2.1	3	1	3
5.2.2	2	1	3
5.3	6	1	3
6.1.1	1	2	1
6.1.2	1	2	1
6.1.3	6	2	3
6.1.4.A	1	2	1
6.1.4.B	1	2	1
6.2.1	2	2	1
6.2.2	1	2	1
7.1.1	1	3	1

Q	MARKS	PST	CDL
7.1.2	3	3	3
7.2.1	1	3	2
7.2.2	2	3	3
7.2.3	3	3	3
7.2.4	4	3	3
7.3.1	2	3	1
7.3.2	5	3	3
8.1.1	2	3	1
8.1.2	2	3	1
8.1.3	2	3	3
8.2.1	6	3	3
8.2.2	4	3	3
8.2.3	3	3	3
9.1	1	3	1
9.2	2	3	3
9.3	2	3	1
9.4	2	3	1
9.5	3	3	3
10.1	2	4	1
10.2	1	4	1
10.3	5	4	3
10.4	5	4	3

Appendix N. Coding of P1 November 2017.

Q	MARKS	PST	CDL
1.1	2	1	2
1.2	2	1	3
1.3	2	1	2
1.4	2	1	2
1.5	2	1	2
1.6	2	2	2
1.7	2	3	2
1.8	2	3	2
1.9	2	3	3
1.10	2	4	2
2.1.1	2	1	1
2.1.2	4	1	3
2.1.3	5	1	3
2.1.4	4	1	3
2.2.1	2	1	1
2.2.2	4	1	3
3.1	3	1	3
3.2	4	1	3
3.3	3	1	3
3.4	4	1	3
4.1	2	1	1
4.2	4	1	3
4.3	5	1	3
5.1	2	1	1
5.2	2	1	3
5.3	3	1	3
5.4	5	1	3
6.1	2	2	1
6.2.1	1	2	3
6.2.2	1	2	3
6.3	6	2	3
7.1	2	3	1
7.2	4	3	3
7.3	3	3	3
7.4	4	3	3

Q	MARKS	PST	CDL
8.1	2	3	1
8.2	4	3	3
8.3	3	3	3
9.1.1	2	3	1
9.1.2	1	3	2
9.1.3	2	3	3
9.1.4	4	3	3
9.2.1	3	3	3
9.2.1	4	3	3
9.2.3	2	3	3
10.1.1	1	3	1
10.1.2	2	3	3
10.2.1	1	3	2
10.2.2	5	3	3
11.1.1	1	4	1
11.1.2	1	4	1
11.2.1	1	4	1
11.2.2	4	4	3
11.2.3	4	4	3
11.2.4	2	4	3

Appendix O. Coding of P1 March 2018.

Q	MARKS	PST	CDL
1.1	2	1	1
1.2	2	1	3
1.3	2	1	3
1.4	2	1	3
1.5	2	1	3
1.6	2	2	1
1.7	2	3	3
1.8	2	3	3
1.9	2	3	1
1.10	2	4	3
2.1	2	1	1
2.2	4	1	3
2.3	6	1	3
2.4	1	1	1
2.5	4	1	3
3.1	1	1	3
3.2	2	1	3
3.3.1	3	1	3
3.3.2	4	1	3
3.4.1	1	1	3
3.4.2	2	1	3
3.4.3	1	1	3
3.5	2	1	2
4.1	2	1	1
4.2	5	1	3
4.3	3	1	3
5.1	2	1	1
5.2	4	1	3
5.3	3	1	3
5.4	3	1	3
5.5	5	1	3
6.1	2	2	1
6.2	2	2	2
6.3	6	2	3
6.4	1	2	1

Q	MARKS	PST	CDL
7.1	2	3	1
7.2	2	3	3
7.3	7	3	3
8.1	2	3	3
8.2	3	3	3
8.3	6	3	3
9.1.1	2	3	1
9.1.2	2	3	3
9.2.1	5	3	3
9.2.2	2	3	2
9.2.3	1	3	1
9.2.4	3	3	2
10.1	3	3	1
10.2.1	2	3	1
10.2.2	4	3	3
11.1.1	2	4	2
11.1.2	2	4	2
11.1.3	1	4	1
11.2.1	2	4	1
11.2.2	3	4	3
11.2.3	3	4	3

The findings of the physics topic and cognitive demand classification of the Guidelines 2015 is presented using the:

- Guidelines 2015 physics topic weighting (Table 51).
- Guidelines 2015 cognitive demand distribution (Table 52).
- Guidelines 2015 frequency matrix (Table 53).
- CAPS 2015 frequency matrix (Table 54).
- CAPS 2015 ratio matrix (Table 55)

Table 51 shows that there are 133 content items in the Guidelines 2015. The mechanics topic includes 81 content items, the waves, sound and light topic includes six content items, the electricity and magnetism topic includes 37 content items; and the optical phenomena topic includes nine content items. Table 51 also shows that the Guidelines 2016 most frequently used the mechanics topic and least frequently used the waves, sound and light topic. The physics topic distribution of the Guidelines 2015 in decreasing order of frequency is mechanics (60.9 percent); electricity and magnetism (27.8 percent); optical phenomena (6.8 percent); and waves, sound and light (4.5 percent).

Table 51

Guidelines 2015 Physics Topic Weighting

Physics topic	PST code	Content items	Percentage
Mechanics	1	81	60.9
Waves, sound and light	2	6	4.5
Electricity and magnetism	3	37	27.8
Optical phenomena	4	9	6.8
Total		133	100.0

Table 52 shows that the recall cognitive demand includes 40 content items, the comprehension cognitive demand includes 34 content items, and the application and analysis cognitive demand includes 59 content items. The cognitive demand distribution of the Guidelines 2015 in decreasing order of frequency is application and analysis (44.4 percent); recall (30.1 percent); comprehension (25.6 percent); and synthesis and evaluation (zero percent).

Table 52

Guidelines 2015 Cognitive Demand Level Weighting

Cognitive demand level	CDL code	Content Items	Percent
Recall	1	40	30.1
Comprehension	2	34	25.6
Application and analysis	3	59	44.4
Synthesis and evaluation	4	0	0.0
Total		133	100.0

Figure 23 shows the cognitive demand distribution of the Guidelines 2015 which favours the mechanics topic and the application and analysis cognitive demand. The mechanics topic and the electricity and magnetism topic have similar cognitive demand distributions with application and analysis having the highest frequency followed by the recall cognitive demand and then the comprehension cognitive demand. The waves, sound and light topic and the optical phenomena topic have similar cognitive demand distributions with the comprehension cognitive demand having the highest frequency followed by the recall cognitive demand. The Guidelines 2015 did not use the highest level of the cognitive taxonomy, synthesis and evaluation.

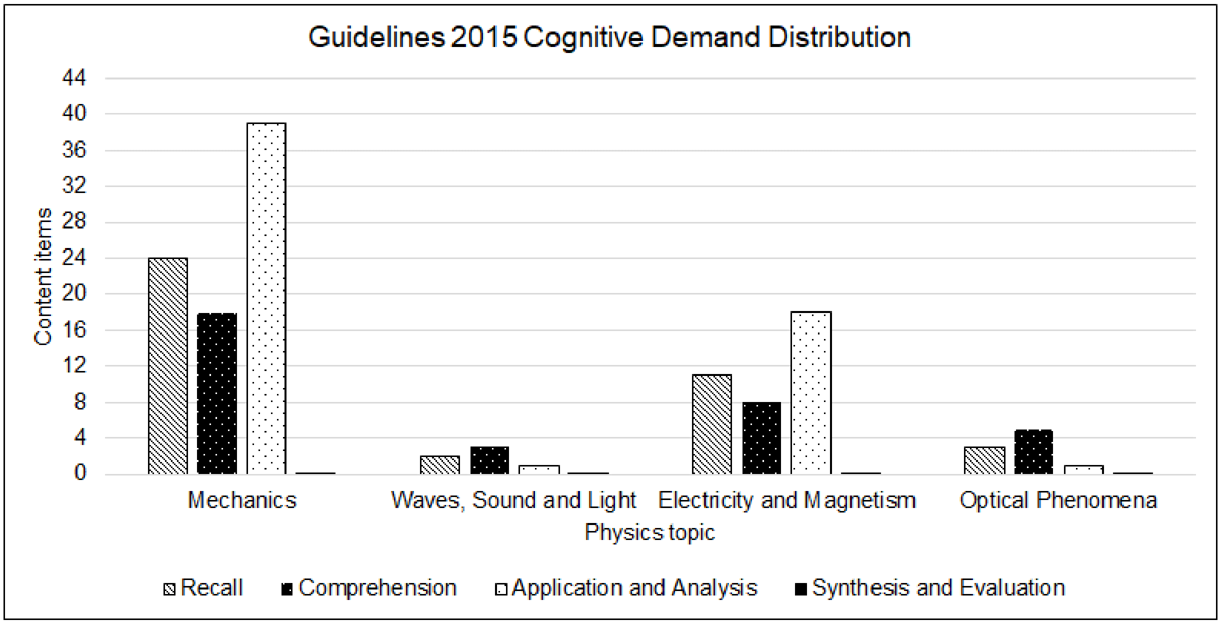


Figure 23. Guidelines 2015 Cognitive Demand Distribution.

Table 53 shows the Guidelines 2015 frequency matrix which was obtained by a tally of each cognitive demand level within each physics topic.

Table 53

Guidelines 2015 Frequency Matrix

Physics topic	Cognitive demand level				Subtotal
	CDL1	CDL2	CDL3	CDL4	
PST1	24	18	39	0	81
PST2	2	3	1	0	6
PST3	11	8	18	0	37
PST4	3	5	1	0	9
Total	40	34	59	59	133

The cell-by-cell addition of the CAPS Grade 12 Physics (Table 23) and the Guidelines 2015 (Table 53) frequency matrices produced the CAPS 2015 frequency matrix shown in Table 54.

Table 54

CAPS 2015 Frequency Matrix

Physics topic	Cognitive demand level				Total
	CDL1	CDL2	CDL3	CDL4	
PST1	58	32	75	0	165
PST2	4	5	3	0	12
PST3	27	16	41	0	84
PST4	8	11	2	0	21
Total	97	64	121	0	282

Diving each cell value of the CAPS 2015 frequency matrix (Table 54) by the CAPS 2015 frequency matrix total (282) produced the CAPS 2015 ratio matrix. Table 55 shows the CAPS 2015 ratio matrix.

Table 55

CAPS 2015 Ratio Matrix

Physics topic	Cognitive demand level			
	CDL1	CDL2	CDL3	CDL4
PST1	0.2057	0.1135	0.2660	0.000
PST2	0.0142	0.0177	0.0106	0.000
PST3	0.0957	0.0567	0.1454	0.000
PST4	0.0284	0.0390	0.0071	0.000

The findings of the physics topic and cognitive demand classification of the Guidelines 2016 is presented using the:

- Guidelines 2016 physics topic weighting (Table 56).
- Guidelines 2016 cognitive demand level weighting (Table 57).
- Guidelines 2016 frequency matrix (Table 58).
- CAPS 2016 frequency matrix (Table 59).
- CAPS 2016 ratio matrix (Table 60).

Table 56 shows that there are 133 content items in the Guidelines 2016. The mechanics topic includes 81 content items, the waves, sound and light topic includes six content items, the electricity and magnetism topic includes 37 content items; and the optical phenomena topic includes nine content items. Table 56 also shows that the Guidelines 2016 most frequently included the mechanics topic and least frequently included the waves, sound and light topic. The physics topic distribution of the Guidelines 2016 in decreasing order of frequency is mechanics (60.9 percent); electricity and magnetism (27.8 percent); optical phenomena (6.8 percent); and waves, sound and light (4.5 percent).

Table 56

Guidelines 2016 Physics Topic Weighting

Physics topic	PST code	Content items	Percentage
Mechanics	1	81	60.9
Waves, sound and light	2	6	4.5
Electricity and magnetism	3	37	27.8
Optical phenomena	4	9	6.8
Total		133	100.0

Table 56 shows that the recall cognitive demand includes 40 content items, the comprehension cognitive demand includes 34 content items, and the application and analysis cognitive demand includes 59 content items. The cognitive demand distribution of the Guidelines 2016 in decreasing order of frequency is application and analysis (44.4 percent); recall (30.1 percent); comprehension (25.6 percent); and synthesis and evaluation (zero percent)

Table 57

Guidelines 2016 Cognitive Demand Level Weighting

Cognitive demand level	CDL code	Content Items	Percent
Recall	1	40	30.1
Comprehension	2	34	25.6
Application and analysis	3	59	44.4
Synthesis and evaluation	4	0	0.0
Total		133	100.0

Figure 24 shows the cognitive demand distribution of the Guidelines 2016 which favours the mechanics topic and the application and analysis cognitive demand. The mechanics topic and the electricity and magnetism topic have similar cognitive demand distributions with the application and analysis cognitive demand having the highest frequency followed by the recall cognitive demand and then the comprehension cognitive demand. The waves, sound and light topic and the optical phenomena topic have similar cognitive demand distributions with the comprehension cognitive demand having the highest frequency followed by the recall cognitive demand. The Guidelines 2016 did not include the synthesis and evaluation cognitive demand.

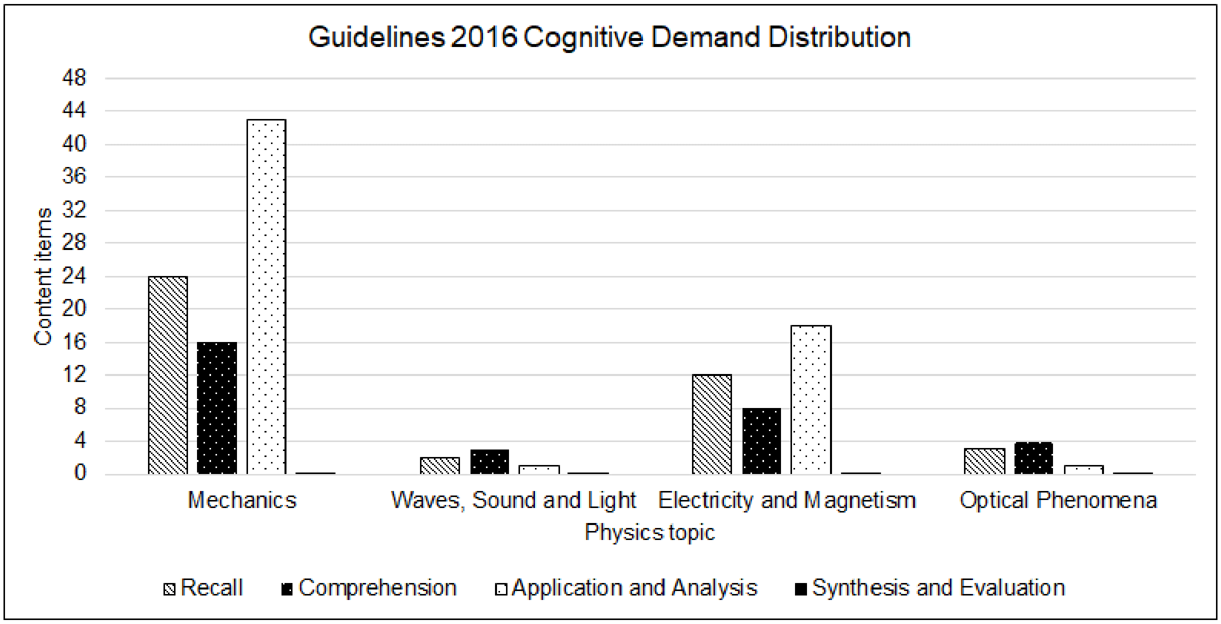


Figure 24. Guidelines 2016 Cognitive Demand Distribution.

Table 58 shows the Guidelines 2016 frequency matrix which was obtained by a tally of each cognitive demand level within each physics topic.

Table 58

Guidelines 2016 Frequency Matrix

Physics topic	Cognitive demand level				Subtotal
	CDL1	CDL2	CDL3	CDL4	
PST1	24	16	43	0	83
PST2	2	3	1	0	6
PST3	12	8	18	0	38
PST4	3	4	1	0	8
Total	41	31	63	0	135

The cell-by-cell addition of the CAPS Grade 12 Physics (Table 23) and the Guidelines 2016 (Table 58) frequency matrices produced the CAPS 2016 frequency matrix shown in Table 59.

Table 59

CAPS 2016 Frequency Matrix

Physics topic	Cognitive demand level				Total
	CDL1	CDL2	CDL3	CDL4	
PST1	58	30	79	0	167
PST2	4	5	3	0	12
PST3	28	16	41	0	85
PST4	8	10	2	0	20
Total	98	61	125	0	284

A cell-by-cell division of the CAPS 2016 frequency matrix (Table 59) by the CAPS 2016 frequency matrix total (284) resulted in the CAPS 2016 ratio matrix. Table 60 shows the CAPS 2016 ratio matrix.

Table 60

CAPS 2016 Ratio Matrix

Physics topic	Cognitive demand level			
	CDL1	CDL2	CDL3	CDL4
PST1	0.2057	0.1135	0.2660	0.0000
PST2	0.0142	0.0177	0.0106	0.0000
PST3	0.0957	0.0567	0.1454	0.0000
PST4	0.0284	0.0390	0.0071	0.0000

The findings of the physics topic and cognitive demand classification of the Guidelines 2017 is presented using the:

Appendix R. Findings of the Guidelines 2017 Analysis

- Guidelines 2017 physics topic weighting (Table 61).
- Guidelines 2017 cognitive demand level weighting (Table 62).
- Guidelines 2017 cognitive demand distribution (Figure 25).
- Guidelines 2017 frequency matrix (Table 63).

CAPS 2017 frequency matrix (

- Table 64).
- CAPS 2017 ratio matrix (Table 65).

Table 61 shows that there are 124 content items in the Guidelines 2017. The mechanics topic includes 73 content items, the waves, sound and light topic includes six content items, the electricity and magnetism topic includes 37 content items; and the optical phenomena topic includes eight content items. Table 61 also shows that the Guidelines 2016 most frequently used the mechanics topic and least frequently used the waves, sound and light topic. The physics topic distribution of the Guidelines 2017 in decreasing order of frequency is mechanics (58.9 percent); electricity and magnetism (29.8 percent); optical phenomena (6.5 percent); and waves, sound and light (4.8 percent).

Table 61

Guidelines 2017 Physics Topic Weighting

Physics topic	PST code	Content items	Percentage
Mechanics	1	73	58.9
Waves, sound and light	2	6	4.8
Electricity and magnetism	3	37	29.8
Optical phenomena	4	8	6.5
Total		124	100.0

Table 62 shows that the recall cognitive demand comprises 33 content items, the comprehension cognitive demand comprises 35 content items, and the application and analysis cognitive demand comprises 56 content items. The cognitive demand distribution of the Guidelines 2017 in decreasing order of frequency are application and analysis (45.2 percent); comprehension (28.2 percent); recall (26.6 percent); and synthesis and evaluation (zero percent)

Table 62

Guidelines 2017 Cognitive Demand Weighting

Cognitive demand level	CDL code	Content Items	Percent

Recall	1	33	26.6
Comprehension	2	35	28.2
Application and analysis	3	56	45.2
Synthesis and evaluation	4	0	0
Total		133	100.0

Figure 25 shows the cognitive demand distribution of the Guidelines 2017 which favours the mechanics topic and the application and analysis cognitive demand. The mechanics and the electricity and magnetism topics have similar cognitive demand distributions with the application and analysis cognitive demand having the highest frequency followed by the recall cognitive demand and then the comprehension cognitive demand. The waves, sound and light topic and the optical phenomena topic have similar cognitive demand distributions with the comprehension cognitive demand having the highest frequency followed by the recall cognitive demand. The Guidelines 2017 did not use the highest level of the cognitive taxonomy, synthesis and evaluation.

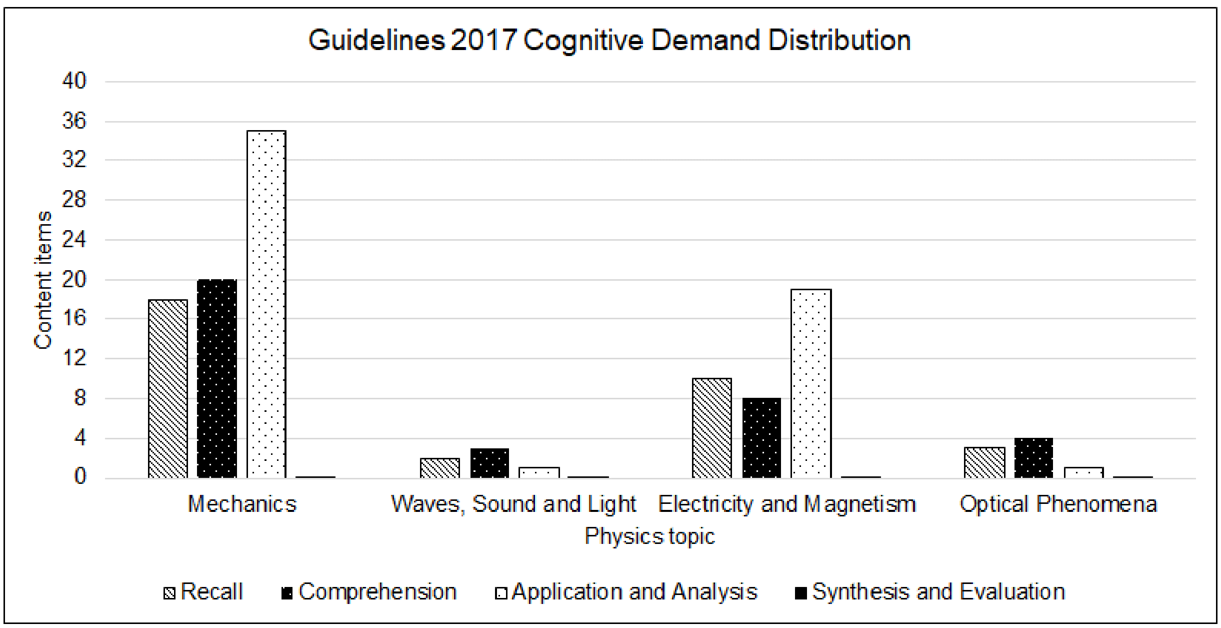


Figure 25. Guidelines 2017 Cognitive Demand Distribution.

Table 63 shows the Guidelines 2017 frequency matrix which was obtained by a tally of each cognitive demand level within each physics topic.

Table 63

Guidelines 2017 Frequency Matrix

Physics topic	Cognitive demand level				Subtotal
	CDL1	CDL2	CDL3	CDL4	
PST1	24	16	43	0	83
PST2	2	3	1	0	6
PST3	12	8	18	0	38
PST4	3	4	1	0	8
Total	41	31	63	0	135

The cell-by-cell addition of the CAPS Grade 12 Physics (Table 23) and the Guidelines 2017 (Table 63) frequency matrices produced the CAPS 2017 frequency matrix shown in

Table 64.

Table 64

CAPS 2017 Frequency Matrix

Physics topic	Cognitive demand level				Total
	CDL1	CDL2	CDL3	CDL4	
PST1	52	34	71	0	157
PST2	4	5	3	0	12
PST3	26	16	42	0	84
PST4	8	10	2	0	20
Total	90	65	118	0	273

A cell-by-cell division of the CAPS 2017 frequency matrix (Table 64) by the CAPS 2017 frequency matrix total (273) resulted in the CAPS 2017 ratio matrix. Table 65 shows the CAPS 2017 ratio matrix.

Table 65

CAPS 2017 Ratio Matrix

Physics topic	Cognitive demand level			
	CDL1	CDL2	CDL3	CDL4
PST1	0.1905	0.1245	0.2601	0.0000
PST2	0.0147	0.0183	0.0110	0.0000
PST3	0.0952	0.0586	0.1538	0.0000
PST4	0.0293	0.0366	0.0073	0.0000

The findings of the P1 March 2015 analysis are presented using the:

- P1 March 2015 physics topic weighting (Table 66).
- P1 March 2015 cognitive demand weighting (Table 67).
- P1 March 2015 cognitive demand distribution (Figure 26).
- P1 March 2015 frequency matrix (Table 68).
- P1 March 2015 ratio matrix (Table 69).
- CAPS 2014 – P1 March 2015 absolute differences matrix (Table 70).

Table 66 shows that there are 57 questions in the P1 March 2015. The mechanics topic included 20 questions, the waves, sound and light topic included five questions, the electricity and magnetism topic included 16 questions, and the optical phenomena topic included seven questions. The physics topic weighting of the P1 March 2015 in decreasing order of frequency is mechanics (41.7 percent); electricity and magnetism (33.3 percent); optical phenomena (14.6 percent); and waves, sound and light (10.4 percent).

Table 66

P1 March 2015 Physics Topic Weighting

Physics topic	PST code	Questions	Percent
Mechanics	1	20	41.7
Waves, sound and light	2	5	10.4
Electricity and magnetism	3	16	33.3
Optical phenomena	4	7	14.6
Total		48	100.0

The cognitive demand analysis of the P1 March 2015 revealed that the recall cognitive demand included 13 questions, the comprehension cognitive demand included nine questions, and the application and analysis cognitive demand included 26 questions. The P1 March 2015 did not use the synthesis and evaluation cognitive demand. The cognitive demand weighting of the P1 March

2015 in decreasing order of frequency is application and analysis (54.2 percent); recall (27.1 percent); comprehension (18.8 percent); and synthesis and evaluation (zero percent).

Table 67 shows the cognitive demand weighting of the P1 March 2015.

Table 67

P1 March 2015 Cognitive Demand Weighting

Cognitive demand level	CDL code	Questions	Percent
Recall	1	13	27.1
Comprehension	2	9	18.8
Application and analysis	3	26	54.2
Synthesis and evaluation	4	0	0.0
Total		48	100.0

Figure 26 shows the cognitive demand distribution of the P1 March 2015.

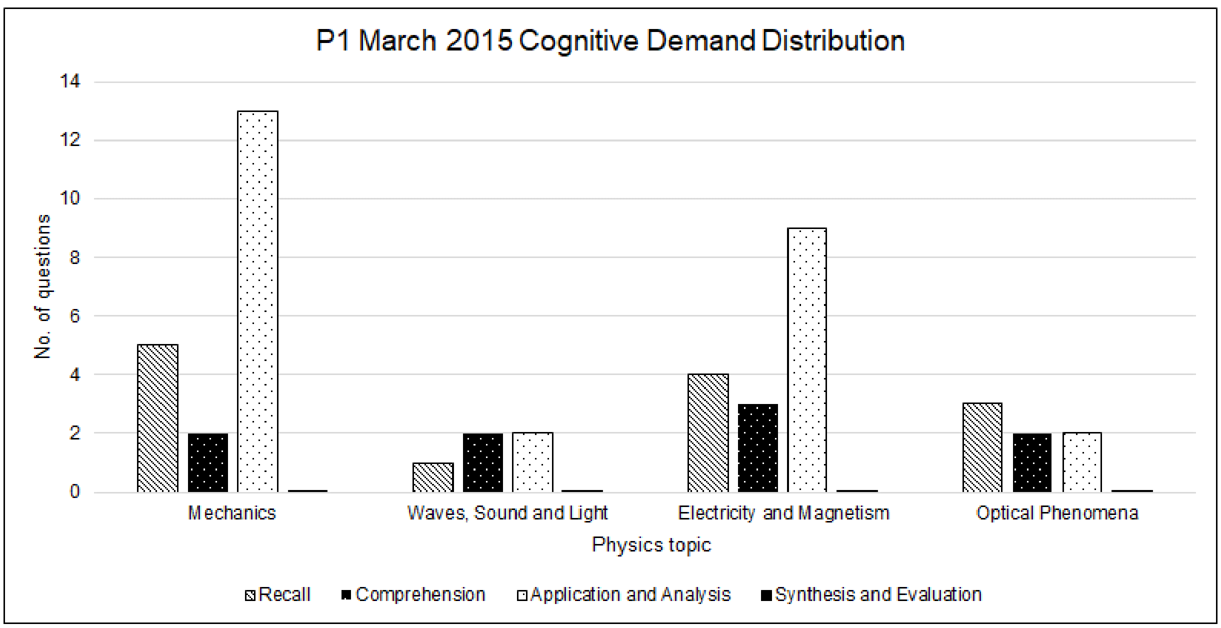


Figure 26. P1 March 2015 Cognitive Demand Distribution.

Table 68 shows a tally of each cognitive demand level within each physics topic.

Table 68

P1 March 2015 Frequency Matrix

Physics topic	Cognitive demand level				Total
	CDL1	CDL2	CDL3	CDL4	
PST1	5	2	13	0	20
PST2	1	2	2	0	5
PST3	4	3	9	0	16
PST4	3	2	2	0	7
Total	13	9	26	0	48

A cell-by-cell division of the P1 March 2015 frequency matrix (Table 68) by the P1 March 2015 frequency matrix total (48) resulted in the P1 March 2015 ratio matrix. Table 69 shows the P1 March 2015 ratio matrix.

Table 69

P1 March 2015 Ratio Matrix

Physics topic	Cognitive demand level			
	CDL1	CDL2	CDL3	CDL4
PST1	0.1042	0.0417	0.2708	0.000
PST2	0.0208	0.0417	0.0417	0.000
PST3	0.0833	0.0625	0.1875	0.000
PST4	0.0625	0.0417	0.0417	0.000

The absolute value of the difference between the CAPS 2014 ratio matrix (Table 29) and the P1 March 2015 ratio matrix (Table 69) produced the CAPS 2014 – P1 November 2014 absolute differences matrix. Table 70 shows the CAPS 2014 – P1 March 2015 absolute differences matrix.

The CAPS 2014 – P1 March 2015 absolute differences matrix total (0.3785) was used in Porter's alignment equation (Section 3.8.1) to calculate the AI (0.8107) between the CAPS 2014 and the P1 March 2015.

Table 70

CAPS – P1 March 2015 Absolute Differences Matrix

Physics topic	Cognitive demand level			
	CDL1	CDL2	CDL3	CDL4
PST1	0.1396	0.0461	0.0749	0.000
PST2	0.0066	0.0239	0.0310	0.000
PST3	0.0332	0.0474	0.0213	0.000
PST4	0.0341	0.0027	0.0346	0.000

Appendix T Findings of the P1 November 2015 Analysis.

The findings of the P1 November 2015 analysis are presented using the:

- P1 November 2015 physics topic weighting (Table 71).
- P1 November 2015 cognitive demand weighting (Table 72).
- P1 November 2015 cognitive demand distribution (Figure 27).
- P1 November 2015 frequency matrix (Table 73).
- P1 November 2015 ratio matrix (Table 74).
- CAPS 2015 – P1 November 2015 absolute differences matrix (Table 75).

Table 67 shows that there are 50 questions in the P1 November 2015. The mechanics topic included 21 questions, the waves, sound and light topic included six questions, the electricity and magnetism topic included 18 questions, and the optical phenomena topic included five questions. The physics topic weighting of the P1 November 2015 in decreasing order of frequency is mechanics (42 percent); electricity and magnetism (36 percent); optical phenomena (12 percent); and waves, sound and light (10 percent).

Table 71
P1 November 2015 Physics Topic Weighting

Physics topic	PST code	Questions	Percent
Mechanics	1	21	42
Waves, sound and light	2	6	12
Electricity and magnetism	3	18	36
Optical phenomena	4	5	10
Total		50	100

The cognitive demand analysis of the P1 November 2015 revealed that the recall cognitive demand included 11 questions, the comprehension cognitive demand included seven questions, and the application and analysis cognitive demand included 32 questions. The P1 November 2015 did not use the synthesis and evaluation cognitive demand. The cognitive demand weighting of the P1

November 2015 in decreasing order of frequency is application and analysis (64 percent); recall (22 percent); comprehension (12 percent); and synthesis and evaluation (zero percent). Table 72 shows the cognitive demand weighting of the P1 November 2015.

Table 72

P1 November 2015 Cognitive Demand Weighting

Cognitive demand level	CDL code	Questions	Percent
Recall	1	11	22
Comprehension	2	7	14
Application and analysis	3	32	64
Synthesis and evaluation	4	0	0
Total		50	100

Figure 27 shows the cognitive demand distribution of the P1 November 2015.

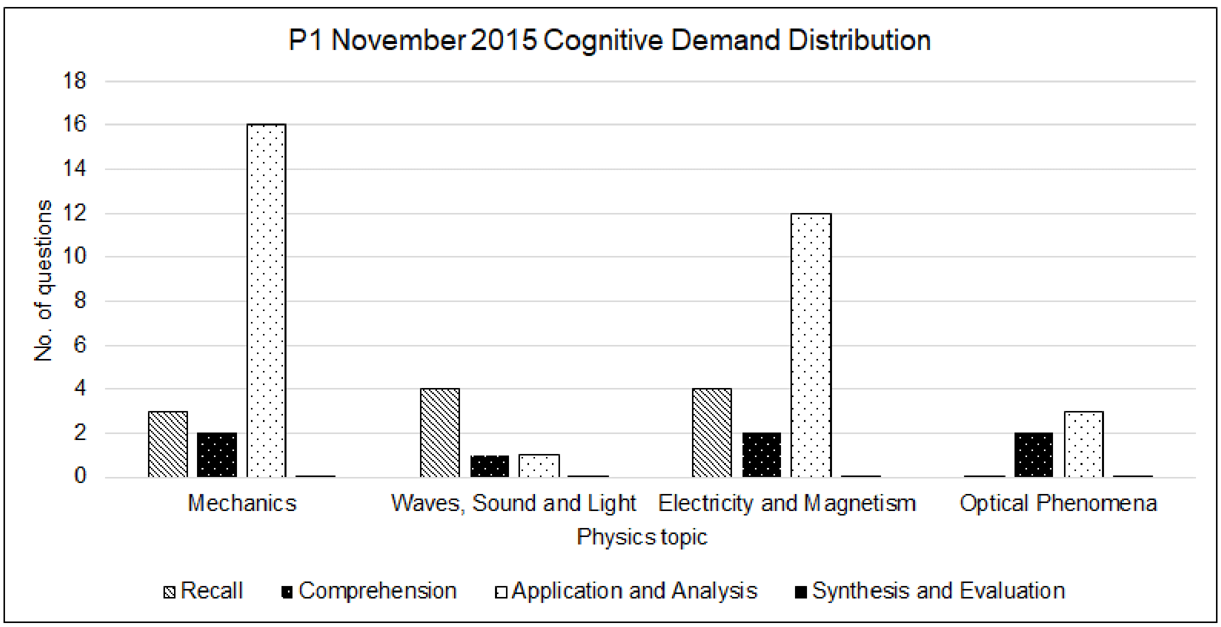


Figure 27. P1 November 2015 Cognitive Demand Distribution.

A tally of each cognitive demand level within each physics topic produced the P1 November 2015 frequency matrix shown in Table 73.

Table 73

P1 November 2015 Frequency Matrix

Physics topic	Cognitive demand level				Total
	CDL1	CDL2	CDL3	CDL4	
PST1	3	2	16	0	21
PST2	4	1	1	0	6
PST3	4	2	12	0	18
PST4	0	2	3	0	5
Total	13	11	7	32	50

A cell-by-cell division of the P1 November 2015 frequency matrix (Table 74) by the P1 November 2015 frequency matrix total (50) resulted in the P1 November 2015 ratio matrix. Table 74 shows the P1 November 2015 ratio matrix.

Table 74

P1 November 2015 Ratio Matrix

Physics topic	Cognitive demand level			
	CDL1	CDL2	CDL3	CDL4
PST1	0.0600	0.0400	0.3200	0.000
PST2	0.0800	0.0200	0.0200	0.000
PST3	0.0800	0.0400	0.2400	0.000
PST4	0.0000	0.0400	0.0600	0.000

The absolute value of the difference between the CAPS 2015 ratio matrix (Table 55) and the P1 November 2015 ratio matrix (Table 74) produced the CAPS 2015 – P1 November 2015 absolute differences matrix. Table 75 shows the CAPS 2015 – P1 November 2015 absolute differences matrix.

The CAPS 2015 – P1 November 2015 absolute differences matrix total (0.5600) was used in Porter's alignment equation (Section 3.8.1) to calculate the AI (0.7200) between the CAPS 2015 and the P1 November 2015.

Table 75

CAPS 2015 – P1 November 2015 Absolute Differences Matrix

Physics topic	Cognitive demand level			
	CDL1	CDL2	CDL3	CDL4
PST1	0.1657	0.0065	0.0060	0.000
PST2	0.0458	0.0223	0.0094	0.000
PST3	0.0157	0.0233	0.0546	0.000
PST4	0.0084	0.0190	0.0529	0.000

The findings of the P1 March 2016 analysis are presented using the:

- P1 March 2016 physics topic weighting (Table 76).

Appendix U Findings of the P1 March 2016 Analysis.

- P1 March 2016 cognitive demand weighting (Table 77).
- P1 March 2016 cognitive demand distribution (Figure 28).
- P1 March 2016 frequency matrix (Table 78).
- P1 March 2016 ratio matrix (Table 79).
- CAPS 2015 – P1 March 2016 absolute differences matrix (Table 80).

Table 76 shows that there are 50 questions in the P1 March 2016. The mechanics topic included 24 questions, the waves, sound and light topic included four questions, the electricity and magnetism topic included 16 questions, and the optical phenomena topic included six questions. The physics topic weighting of the P1 March 2016 in decreasing order of frequency is mechanics (48 percent); electricity and magnetism (32 percent); optical phenomena (12 percent); and waves, sound and light (8 percent).

Table 76

P1 March 2016 Physics Topic Weighting

Physics topic	PST code	Questions	Percent
Mechanics	1	24	48
Waves, sound and light	2	4	8
Electricity and magnetism	3	16	32
Optical phenomena	4	6	12
Total		50	100

The cognitive demand analysis of the P1 March 2016 revealed that the recall cognitive demand included 11 questions, the comprehension cognitive demand included seven questions, and the application and analysis cognitive demand included 32 questions. The P1 March 2016 did not use the synthesis and evaluation cognitive demand. The cognitive demand weighting of the P1 March

2016 in decreasing order of frequency is application and analysis (64 percent); recall (22 percent); comprehension (14 percent); and synthesis and evaluation (zero percent).

Table 77 shows the cognitive demand weighting of the P1 March 2016.

Table 77

P1 March 2016 Cognitive Demand Weighting

Cognitive demand level	CDL code	Questions	Percent
Recall	1	7	22
Comprehension	2	11	14
Application and analysis	3	32	64
Synthesis and evaluation	4	0	0
Total		50	100

Figure 28 shows cognitive demand distribution of the P1 March 2016.

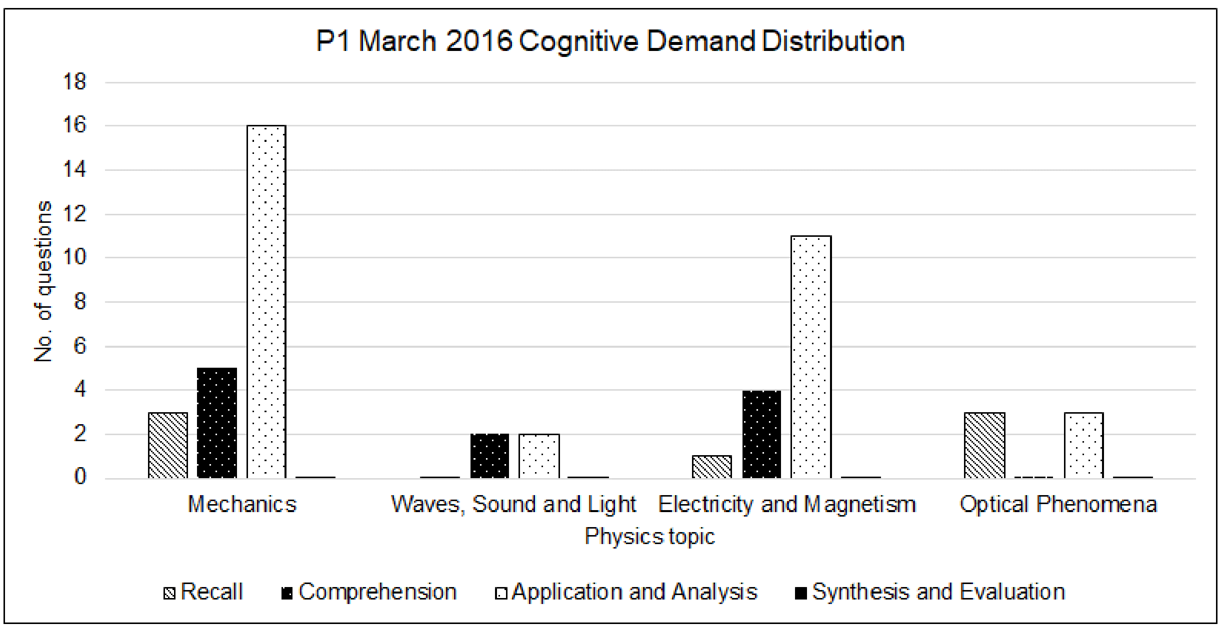


Figure 28. P1 March 2016 Cognitive Demand Distribution.

Table 78 shows a tally of each cognitive demand level within each physics topic.

Table 78

P1 March 2016 Frequency Matrix

Physics topic	Cognitive demand level				Total
	CDL1	CDL2	CDL3	CDL4	
PST1	3	5	16	0	21
PST2	0	2	2	0	6
PST3	1	4	11	0	18
PST4	3	0	3	0	5
Total	7	11	32	0	50

A cell-by-cell division of the P1 March 2016 frequency matrix (Table 78) by the P1 March 2016 frequency matrix total (50) resulted in the P1 March 2016 ratio matrix. Table 79 shows the P1 March 2016 ratio matrix.

Table 79

P1 March 2016 Ratio Matrix

Physics topic	Cognitive demand level			
	CDL1	CDL2	CDL3	CDL4
PST1	0.0600	0.0400	0.3200	0.000
PST2	0.0800	0.0200	0.0200	0.000
PST3	0.0800	0.0400	0.2400	0.000
PST4	0.0000	0.0400	0.0600	0.000

The absolute value of the difference between the CAPS 2015 ratio matrix (Table 55) and the P1 March 2016 ratio matrix (Table 79) produced the CAPS 2015 – P1 March 2016 absolute differences matrix. Table 80 shows the CAPS 2015 – P1 March 2016 absolute differences matrix.

The CAPS 2015 – P1 March 2016 absolute differences matrix total (0.5762) was used in Porter’s alignment equation (Section 3.8.1) to calculate the AI (0.7119) between the CAPS 2015 and the P1 March 2016.

Table 80

CAPS 2015 – P1 March 2016 Absolute Differences Matrix

Physics topic	Cognitive demand level			
	CDL1	CDL2	CDL3	CDL4
PST1	0.1657	0.0065	0.0060	0.000
PST2	0.0458	0.0223	0.0094	0.000
PST3	0.0157	0.0233	0.0546	0.000
PST4	0.0084	0.0190	0.0529	0.000

The findings of the P1 November 2016 analysis are presented using the:

- P1 November 2016 physics topic weighting (Table 81).
- P1 November 2016 cognitive demand weighting (Table 82).
- P1 November 2016 cognitive demand distribution (Figure 29).
- P1 November 2016 frequency matrix (Table 83).
- P1 November 2016 ratio matrix (Table 84).
- CAPS 2016 – P1 November 2016 absolute differences matrix (Table 85).

Table 81 shows that there are 56 questions in the P1 November 2016. The mechanics topic included 22 questions, the waves, sound and light topic included six questions, the electricity and magnetism topic included 21 questions, and the optical phenomena topic included seven questions. The physics topic weighting of the P1 November 2016 in decreasing order of frequency is mechanics (39.3 percent); electricity and magnetism (37.5 percent); optical phenomena (12.5 percent); and waves, sound and light (10.7 percent).

Table 81

P1 November 2016 Physics Topic Weighting

Physics topic	PST code	Questions	Percent
Mechanics	1	22	39.3
Waves, sound and light	2	6	10.7
Electricity and magnetism	3	21	37.5
Optical phenomena	4	7	12.5
Total		56	100

The cognitive demand analysis of the P1 November 2016 revealed that the recall cognitive demand included 13 questions, the comprehension cognitive demand included 12 questions, and the application and analysis cognitive demand included 31 questions. The P1 November 2016 did not include the synthesis and evaluation cognitive demand. The cognitive demand weighting of the P1

November 2016 in decreasing order of frequency is application and analysis (55.4 percent); recall (23.2 percent); comprehension (21.4 percent); and synthesis and evaluation (zero percent. Table 82 shows the cognitive demand weighting of the P1 November 2016.

Table 82

P1 November 2016 Cognitive Demand Weighting

Cognitive demand level	CDL code	Questions	Percent
Recall	1	13	23.2
Comprehension	2	12	21.4
Application and analysis	3	31	55.4
Synthesis and evaluation	4	0	0.0
Total		50	100.0

Note. CDL, cognitive demand level.

Figure 29 shows the cognitive demand distribution of the P1 November 2016.

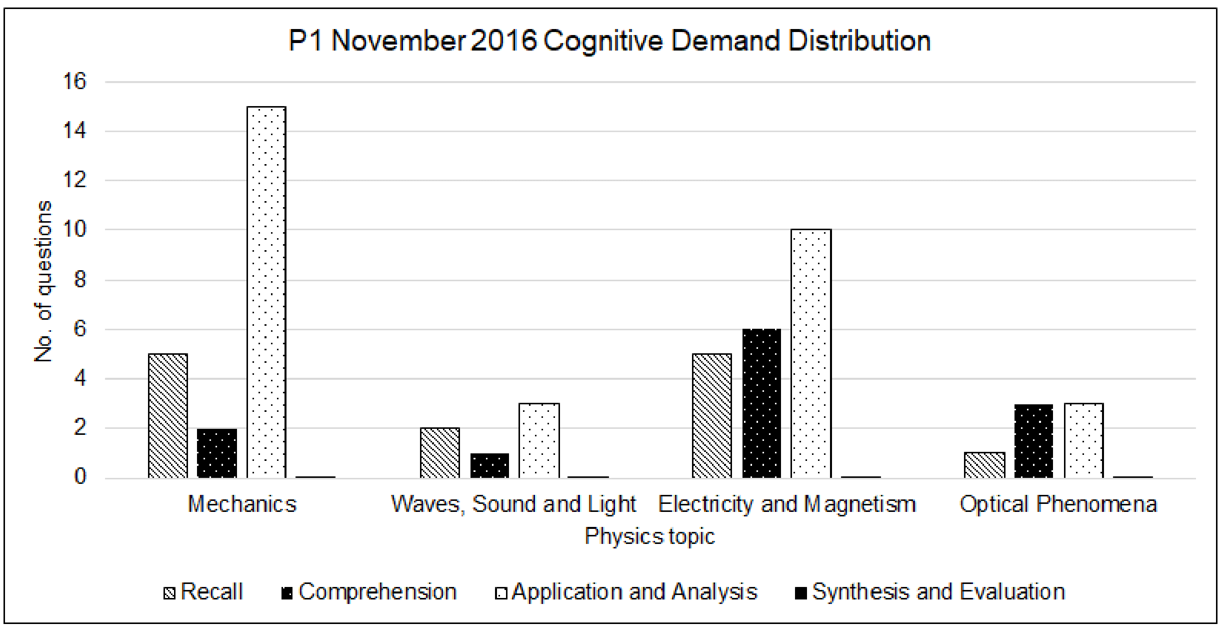


Figure 29. P1 November 2016 Cognitive Demand Distribution.

A tally of each cognitive demand level within each physics topic produced the P1 November 2016 frequency matrix shown in Table 83.

Table 83

P1 November 2016 Frequency Matrix

Physics topic	Cognitive demand level				Total
	CDL1	CDL2	CDL3	CDL4	
PST1	5	2	15	0	22
PST2	2	1	3	0	6
PST3	5	6	10	0	21
PST4	1	3	3	0	7
Total	13	12	31	0	56

A cell-by-cell division of the P1 November 2016 frequency matrix (Table 83) by the P1 November 2016 frequency matrix total (56) produced the P1 November 2016 ratio matrix. Table 84 shows the P1 November 2016 ratio matrix.

Table 84

P1 November 2016 Ratio Matrix

Physics topic	Cognitive demand level			
	CDL1	CDL2	CDL3	CDL4
PST1	0.0893	0.0357	0.2679	0.000
PST2	0.0357	0.0179	0.0536	0.000
PST3	0.0893	0.1071	0.1786	0.000
PST4	0.0179	0.0536	0.0536	0.000

The absolute value of the difference between the CAPS 2016 ratio matrix (Table 60) and the P1 November 2016 ratio matrix (Table 84) produced the CAPS 2016 – P1 November 2016 absolute differences matrix. Table 80 shows the CAPS 2016 – P1 November 2016 absolute differences matrix.

The CAPS 2016 – P1 November 2016 absolute differences matrix total (0.4296) was used in Porter's alignment equation (Section 3.8.1) to calculate the AI (0.7852) between the CAPS 2016 and the P1 November 2016.

Table 85

CAPS 2015 – P1 November 2016 Absolute Differences Matrix

Physics topic	Cognitive demand level			
	CDL1	CDL2	CDL3	CDL4
PST1	0.1149	0.0699	0.0103	0.000
PST2	0.0216	0.0003	0.0430	0.000
PST3	0.0093	0.0508	0.0342	0.000
PST4	0.0103	0.0184	0.0465	0.000

Appendix W. Findings of the P1 March 2017 Analysis.

The findings of the P1 March 2017 analysis are presented using the:

- P1 March 2017 physics topic weighting (Table 86).
- P1 March 2017 cognitive demand weighting (Table 87).
- P1 March 2017 cognitive demand distribution (Figure 30).
- P1 March 2017 frequency matrix (Table 88).
- P1 March 2017 ratio matrix (Table 89).
- CAPS 2016 – P1 March 2017 absolute differences matrix (Table 90).

Table 82 shows that there are 57 questions in the P1 March 2017. The mechanics topic included 22 questions, the waves, sound and light topic included eight questions, the electricity and magnetism topic included 22 questions, and the optical phenomena topic included five questions. The physics topic weighting of the P1 March 2017 in decreasing order of frequency is mechanics (38.6 percent); electricity and magnetism (38.6 percent); waves, sound and light (14.0 percent); and optical phenomena (8.8 percent).

Table 86

P1 March 2017 Physics Topic Weighting

Physics topic	PST code	Questions	Percent
Mechanics	1	22	38.6
Waves, sound and light	2	8	14.0
Electricity and magnetism	3	22	38.6
Optical phenomena	4	5	8.8
Total		57	100.0

The cognitive demand analysis of the P1 March 2017 revealed that the recall cognitive demand included 22 questions, the comprehension cognitive demand included seven questions, and the application and analysis cognitive demand included 28 questions. The P1 March 2017 did not include the synthesis and evaluation cognitive demand. The cognitive demand weighting of the P1

March 2017 in decreasing order of frequency is application and analysis (49.1 percent); recall (38.6 percent); comprehension (12.3 percent); and synthesis and evaluation (zero percent). Table 87 shows the cognitive demand weighting of the P1 March 2017.

Table 87

P1 March 2017 Cognitive Demand Weighting

Cognitive demand level	CDL code	Questions	Percent
Recall	1	22	38.6
Comprehension	2	7	12.3
Application and analysis	3	28	49.1
Synthesis and evaluation	4	0	0.0
Total		57	100.0

Note. CDL, cognitive demand level.

Figure 30 shows the cognitive demand distribution of the P1 March 2017.

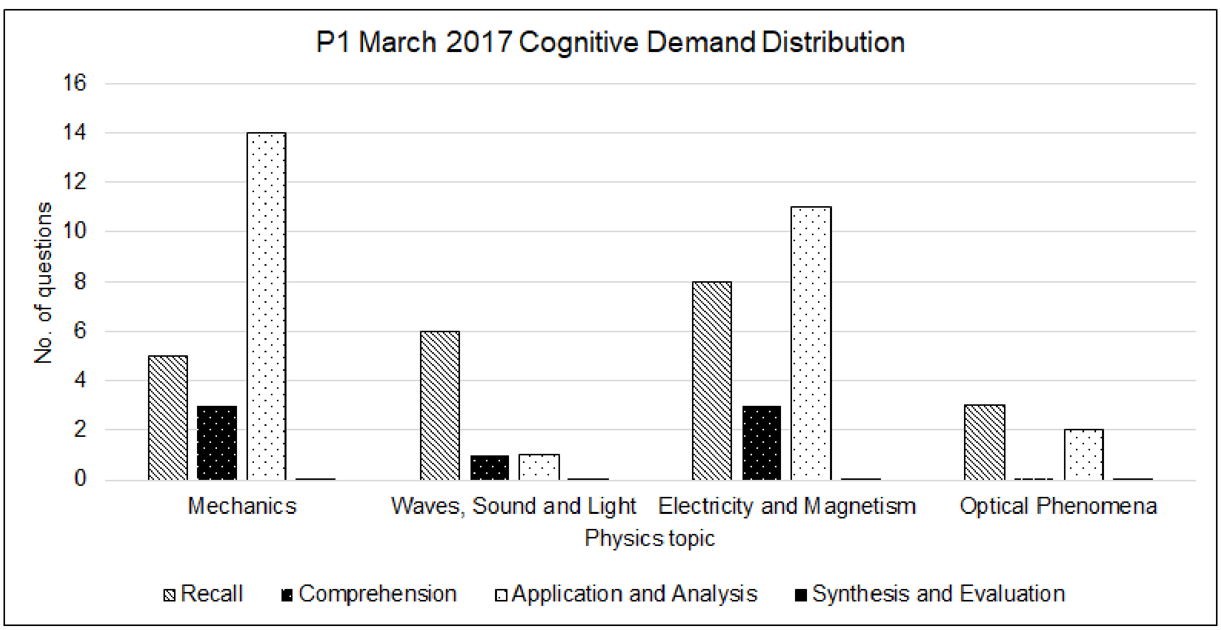


Figure 30. P1 March 2017 Cognitive Demand Distribution.

A tally of each cognitive demand level within each physics topic produced the P1 March 2017 frequency matrix shown in Table 88.

Table 88

P1 March 2017 Frequency Matrix

Physics topic	Cognitive demand level				Total
	CDL1	CDL2	CDL3	CDL4	
PST1	5	3	14	0	22
PST2	6	1	1	0	8
PST3	8	3	11	0	22
PST4	3	0	2	0	5
Total	22	7	28	0	57

A cell-by-cell division of the P1 March 2017 frequency matrix (Table 88) by the P1 March 2017 frequency matrix total (57) produced the P1 March 2017 ratio matrix. Table 89 shows the P1 March 2017 ratio matrix.

Table 89

P1 March 2017 Ratio Matrix

Physics topic	Cognitive demand level			
	CDL1	CDL2	CDL3	CDL4
PST1	0.0877	0.0526	0.2456	0.000
PST2	0.1053	0.0175	0.0175	0.000
PST3	0.1404	0.0526	0.1930	0.000
PST4	0.0526	0.0000	0.0351	0.000

The absolute value of the difference between the CAPS 2016 ratio matrix (Table 60) and the P1 March 2017 ratio matrix (Table 89) produced the CAPS 2016 – P1 March 2017 absolute differences matrix. Table 90 shows the CAPS 2016 – P1 March 2017 absolute differences matrix.

The CAPS 2016 – P1 March 2017 absolute differences matrix total (0.4821) was used in Porter's alignment equation (Section 3.8.1) to calculate the AI (0.7590) between the CAPS 2016 and the P1 March 2017.

Table 90

CAPS 2016 – P1 March 2017 Absolute Differences Matrix

Physics topic	Cognitive demand level			
	CDL1	CDL2	CDL3	CDL4
PST1	0.1165	0.0530	0.0326	0.000
PST2	0.0912	0.0001	0.0070	0.000
PST3	0.0418	0.0037	0.0486	0.000
PST4	0.0245	0.0352	0.0280	0.000

The findings of the P1 March 2017 analysis are presented using the:

- P1 November 2017 physics topic weighting (Table 91).
- P1 November 2017 cognitive demand weighting (Table 92).
- P1 November 2017 cognitive demand distribution (Figure 31).
- P1 November 2017 frequency matrix (Table 93).
- P1 November 2017 ratio matrix (Table 94).
- CAPS 2017 – P1 November 2017 absolute differences matrix (Table 95).

Table 91 shows that there are 55 questions in the P1 November 2017. The mechanics topic included 22 questions, the waves, sound and light topic included five questions, the electricity and magnetism topic included 21 questions, and the optical phenomena included seven questions. The physics topic weighting of the P1 November 2017 in decreasing order of frequency is mechanics (40.0 percent); electricity and magnetism (38.2 percent); optical phenomena (12.7 percent); and waves, sound and light (9.1 percent).

Table 91

P1 November 2017 Physics Topic Weighting

Physics topic	PST code	Questions	Percent
Mechanics	1	22	40.0
Waves, sound and light	2	5	9.1
Electricity and magnetism	3	21	38.2
Optical phenomena	4	7	12.7
Total		55	100.0

The cognitive demand analysis of the P1 November 2017 revealed that the recall cognitive demand included 12 questions, the comprehension cognitive demand included 10 questions, and the application and analysis cognitive demand included 33 questions. The P1 November 2017 did not use the synthesis and evaluation cognitive demand. The cognitive demand weighting of the P1

November 2017 in decreasing order of frequency is application and analysis (60.0 percent); recall (21.8 percent); comprehension (18.2 percent); and synthesis and evaluation (zero percent). Table 92 shows the cognitive demand weighting of the P1 November 2017.

Table 92

P1 November 2017 Cognitive Demand Weighting

Cognitive demand level	CDL code	Questions	Percent
Recall	1	12	21.8
Comprehension	2	10	18.2
Application and analysis	3	33	60.0
Synthesis and evaluation	4	0	0.0
Total		55	100.0

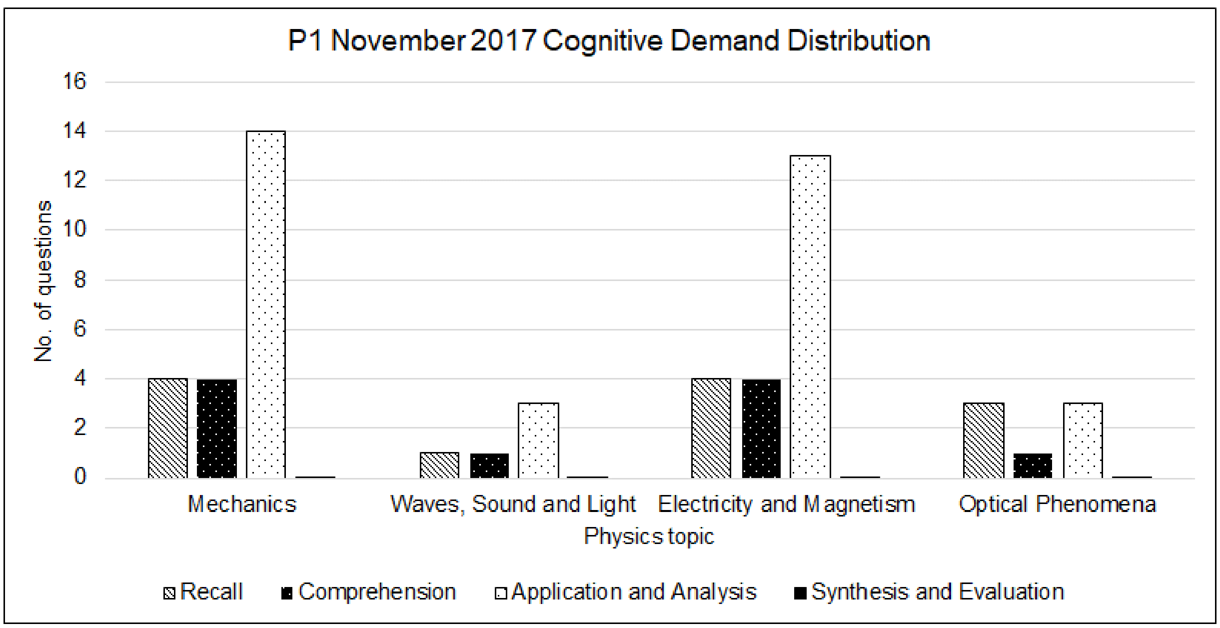


Figure 31. P1 November 2017 Cognitive Demand Distribution.

Figure 31 shows the cognitive demand distribution of the P1 November 2017.

Table 93 shows a tally of each cognitive demand level within each physics topic.

Table 93

P1 November 2017 Frequency Matrix

Physics topic	Cognitive demand level				Total
	CDL1	CDL2	CDL3	CDL4	
PST1	4	4	14	0	22
PST2	1	1	3	0	5
PST3	4	4	13	0	21
PST4	3	1	3	0	7
Total	12	10	33	0	55

A cell-by-cell division of the P1 November 2017 frequency matrix (Table 93) by the P1 November 2017 frequency matrix total (57) produced the P1 November 2017 ratio matrix. Table 94 shows the P1 March 2017 ratio matrix.

Table 94

P1 November 2017 Ratio Matrix

Physics topic	Cognitive demand level			
	CDL1	CDL2	CDL3	CDL4
PST1	0.0714	0.0714	0.2500	0.000
PST2	0.0179	0.0179	0.0536	0.000
PST3	0.0714	0.0714	0.2321	0.000
PST4	0.0536	0.0179	0.0536	0.000

The absolute value of the difference between the CAPS 2017 ratio matrix (Table 65) and the P1 November 2017 ratio matrix (Table 94) produced the CAPS 2017 – P1 November 2017 absolute differences matrix. Table 90 shows the CAPS 2017 – P1 November 2017 absolute differences matrix.

The CAPS 2017 – P1 November 2017 absolute differences matrix total (0.4327) was used in Porter's alignment equation (Section 3.8.1) to calculate the AI (0.7837) between the CAPS 2017 and the P1 November 2017.

Table 95

CAPS 2016 – P1 November 2017 Absolute Differences Matrix

Physics topic	Cognitive demand level			
	CDL1	CDL2	CDL3	CDL4
PST1	0.1190	0.0531	0.0101	0.000
PST2	0.0032	0.0005	0.0426	0.000
PST3	0.0238	0.0128	0.0783	0.000
PST4	0.0243	0.0188	0.0462	0.000

The findings of the P1 March 2017 analysis are presented using the:

- P1 March 2018 physics topic weighting (Table 96).
- P1 March 2018 cognitive demand weighting (Table 97).
- P1 March 2018 cognitive demand distribution (Figure 32).
- P1 March 2018 frequency matrix (Table 98).
- P1 March 2018 ratio matrix (Table 99).
- CAPS 2017 – P1 March 2018 absolute differences matrix (Table 100).

Table 96 shows that there are 56 questions in the P1 March 2018. The mechanics topic included 26 questions, the waves, sound and light topic included five questions, the electricity and magnetism topic included 18 questions, and the optical phenomena topic included seven questions. The physics topic weighting of the P1 March 2018 in decreasing order of frequency is mechanics (46.4 percent); electricity and magnetism (32.1 percent); optical phenomena (12.5 percent); and waves, sound and light (8.9 percent)

Table 96

P1 March 2018 Physics Topic Weighting

Physics topic	PST code	Questions	Percent
Mechanics	1	26	46.4
Waves, sound and light	2	5	8.9
Electricity and magnetism	3	18	32.1
Optical phenomena	4	7	12.5
Total		56	100.0

The cognitive demand analysis of the P1 March 2018 revealed that the recall cognitive demand included 12 questions, the comprehension cognitive demand included 10 questions, and the application and analysis cognitive demand included 33 questions. The P1 March 2018 did not include the synthesis and evaluation cognitive demand. The cognitive demand weighting of the P1

March 2018 in decreasing order of frequency is application and analysis (60.0 percent); recall (21.8 percent); comprehension (18.2 percent); and synthesis and evaluation (zero percent). Table 93 shows the cognitive demand weighting of the P1 March 2018.

Table 97

P1 March 2018 Cognitive Demand Weighting

Cognitive demand level	CDL code	Questions	Percent
Recall	1	16	28.6
Comprehension	2	6	10.7
Application and analysis	3	34	60.7
Synthesis and evaluation	4	0	0.0
Total		56	100.0

Table 98 shows a tally of each cognitive demand level within each physics topic.

Table 98

P1 March 2018 Frequency Matrix

Physics topic	Cognitive demand level				Total
	CDL1	CDL2	CDL3	CDL4	
PST1	5	1	20	0	27
PST2	3	1	1	0	5
PST3	6	2	10	0	18
PST4	2	2	3	0	7
Total	16	6	34	0	56

A cell-by-cell division of the P1 March 2018 frequency matrix (Table 98) by the P1 March 2018 frequency matrix total (56) produced the P1 March 2018 ratio matrix. Table 99 shows the P1 March 2018 ratio matrix.

Table 99

P1 March 2018 Ratio Matrix

Physics topic	Cognitive demand level			
	CDL1	CDL2	CDL3	CDL4
PST1	0.0877	0.0175	0.3509	0.000
PST2	0.0526	0.0175	0.0175	0.000
PST3	0.1053	0.0351	0.1754	0.000
PST4	0.0351	0.0351	0.0526	0.000

The absolute value of the difference between the CAPS 2017 ratio matrix (Table 65) and the P1 March 2018 ratio matrix (Table 99) produced the CAPS 2017 – P1 March 2018 absolute differences matrix. Table 100 shows the CAPS 2017 – P1 March 2018 absolute differences matrix.

Figure 32 shows the cognitive demand distribution of the P1 March 2018.

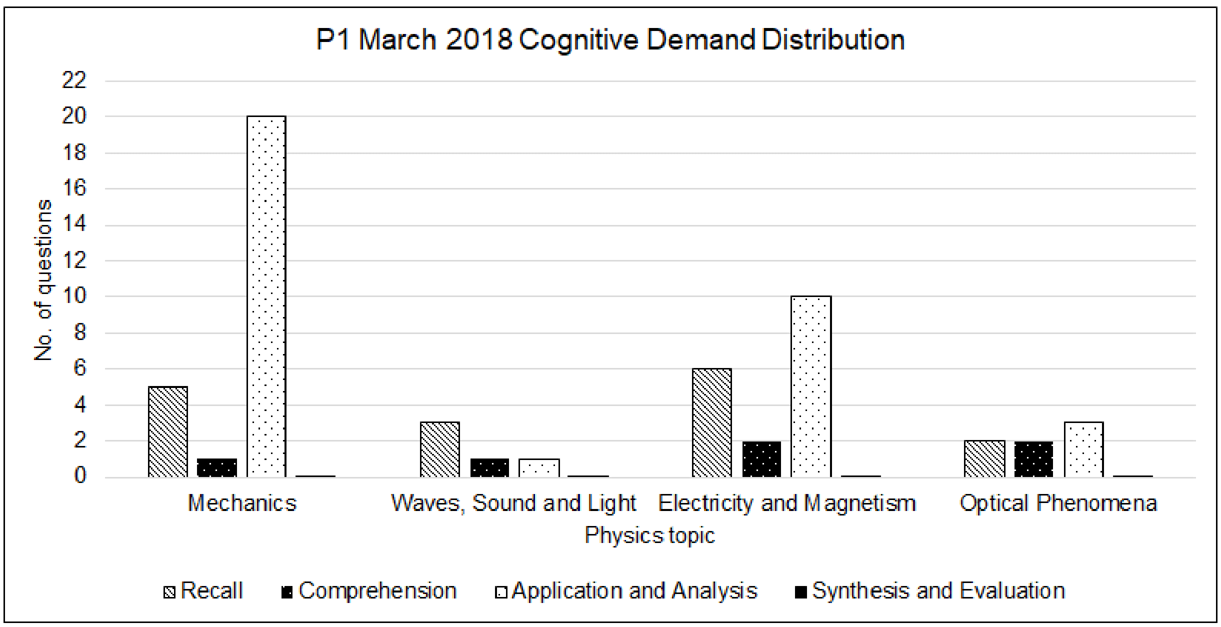


Figure 32. P1 March 2018 Cognitive Demand Distribution.

The CAPS 2017 – P1 March 2018 absolute differences matrix total (0.4536) was used in Porter's alignment equation (Section 3.8.1) to calculate the AI (0.7732) between the CAPS 2017 and the P1 March 2018.

Table 100

CAPS 2017 – P1 March 2018 Absolute Differences Matrix

Physics topic	Cognitive demand level			
	CDL1	CDL2	CDL3	CDL4
PST1	0.1028	0.1070	0.0908	0.000
PST2	0.0380	0.0008	0.0066	0.000
PST3	0.0100	0.0235	0.0216	0.000
PST4	0.0058	0.0015	0.0453	0.000

The CAPS 2017 – P1 March 2018 absolute differences matrix total (0.4536) was used in Porter's alignment equation (Section 3.8.1) to calculate the AI (0.7732) between the CAPS 2017 and the P1 March 2018.

Appendix Z. AI Calculation CAPS – P1 November 2014

Frequency matrices

CAPS			
34	14	36	0
2	2	2	0
16	8	23	0
5	6	1	0

Guidelines 2014			
23	20	38	0
2	3	1	0
11	8	18	0
3	5	1	0

CAPS 2014			
57	34	74	0
4	5	3	0
27	16	41	0
8	11	2	0

P1 November 2014			
5	10	8	0
1	3	1	0
4	12	8	0
2	2	1	0

Ratio matrices

CAPS 2014			
0.2021	0.1206	0.2624	0.0000
0.0142	0.0177	0.0106	0.0000
0.0957	0.0567	0.1454	0.0000
0.0284	0.0390	0.0071	0.0000

P1 November 2014			
0.1404	0.0526	0.2105	0.0000
0.0175	0.0351	0.0351	0.0000
0.1228	0.0702	0.2281	0.0000
0.0351	0.0175	0.0351	0.0000

Absolute differences ratio matrix and AI calculation.

ADM CAPS – P1 November 2014			
0.0618	0.0679	0.0519	0.0000
0.0034	0.0174	0.0244	0.0000
0.0271	0.0134	0.0827	0.0000
0.0067	0.0215	0.0280	0.0000

∑	∑/2	AI
0.4061	0.2031	0.7969

Appendix AA. AI Calculation CAPS – P1 March 2015.

Frequency matrices

CAPS			
34	14	36	0
2	2	2	0
16	8	23	0
5	6	1	0

Guidelines 2014			
23	20	38	0
2	3	1	0
11	8	18	0
3	5	1	0

CAPS 2014			
57	34	74	0
4	5	3	0
27	16	41	0
8	11	2	0

P1 March 2015			
3	8	9	0
1	2	2	0
3	5	8	0
3	2	2	0

Ratio matrices

CAPS 2014			
0.2021	0.1206	0.2624	0.0000
0.0142	0.0177	0.0106	0.0000
0.0957	0.0567	0.1454	0.0000
0.0284	0.0390	0.0071	0.0000

P1 March 2015			
0.1042	0.0417	0.2708	0.0000
0.0208	0.0417	0.0417	0.0000
0.0833	0.0625	0.1875	0.0000
0.0625	0.0417	0.0417	0.0000

Absolute differences ratio matrix and AI calculation.

ADM CAPS – P1 March 2015			
0.0980	0.0789	0.0084	0.0000
0.0066	0.0239	0.0310	0.0000
0.0124	0.0058	0.0421	0.0000
0.0341	0.0027	0.0346	0.0000

∑	∑/2	AI
0.3785	0.1893	0.8107

Appendix BB. AI Calculation CAPS – P1 November 2015

Frequency matrices

CAPS			
34	14	36	0
2	2	2	0
16	8	23	0
5	6	1	0

Guidelines 2015			
24	18	39	0
2	3	1	0
11	8	18	0
3	5	1	0

CAPS 2015			
58	32	75	0
4	5	3	0
27	16	41	0
8	11	2	0

P1 November 2015			
2	6	13	0
3	2	1	0
4	4	10	0
1	1	3	0

Ratio matrices

CAPS 2015			
0.2057	0.1135	0.2660	0.0000
0.0142	0.0177	0.0106	0.0000
0.0957	0.0567	0.1454	0.0000
0.0284	0.0390	0.0071	0.0000

P1 November 2015			
0.0600	0.0400	0.3200	0.0000
0.0800	0.0200	0.0200	0.0000
0.0800	0.0400	0.2400	0.0000
0.0000	0.0400	0.0600	0.0000

Absolute differences ratio matrix and AI calculation.

ADM CAPS – P1 November 2015			
0.1457	0.0735	0.0540	0.0000
0.0658	0.0023	0.0094	0.0000
0.0157	0.0167	0.0946	0.0000
0.0284	0.0010	0.0529	0.0000

∑	∑/2	AI
0.5600	0.2800	0.7200

Appendix CC. AI Calculation CAPS – P1 March 2016.

Frequency matrices

CAPS			
34	14	36	0
2	2	2	0
16	8	23	0
5	6	1	0

Guidelines 2015			
24	18	39	0
2	3	1	0
11	8	18	0
3	5	1	0

CAPS 2015			
58	32	75	0
4	5	3	0
27	16	41	0
8	11	2	0

P1 March 2016			
3	5	16	0
0	2	2	0
1	4	11	0
3	0	3	0

Ratio matrices

CAPS 2015			
0.2057	0.1135	0.2660	0.0000
0.0142	0.0177	0.0106	0.0000
0.0957	0.0567	0.1454	0.0000
0.0284	0.0390	0.0071	0.0000

P1 March 2016			
0.0600	0.1000	0.3200	0.0000
0.0000	0.0400	0.0400	0.0000
0.0200	0.0800	0.2200	0.0000
0.0600	0.0000	0.0600	0.0000

Absolute differences ratio matrix and AI calculation.

ADM CAPS – P1 March 2016			
0.1457	0.0135	0.0540	0.1457
0.0142	0.0223	0.0294	0.0142
0.0757	0.0233	0.0746	0.0757
0.0316	0.0390	0.0529	0.0316

$\sum$	$\sum/2$	AI
0.5762	0.2881	0.7119

Appendix DD. AI Calculation CAPS – P1 November 2016

Frequency matrices

CAPS			
34	14	36	0
2	2	2	0
16	8	23	0
5	6	1	0

Guidelines 2016			
24	16	43	0
2	3	1	0
12	8	18	0
3	4	1	0

CAPS 2016			
58	30	79	0
4	5	3	0
28	16	41	0
8	10	2	0

P1 November 2016			
5	2	15	0
2	1	3	0
5	6	10	0
1	3	3	0

Ratio matrices

CAPS 2016			
0.2042	0.1056	0.2782	0.0000
0.0141	0.0176	0.0106	0.0000
0.0986	0.0563	0.1444	0.0000
0.0282	0.0352	0.0070	0.0000

P1 November 2016			
0.0893	0.0357	0.2679	0.0000
0.0357	0.0179	0.0536	0.0000
0.0893	0.1071	0.1786	0.0000
0.0179	0.0536	0.0536	0.0000

Absolute differences ratio matrix and AI calculation.

ADM CAPS – P1 November 2016			
0.1149	0.0699	0.0103	0.0000
0.0216	0.0003	0.0430	0.0000
0.0093	0.0508	0.0342	0.0000
0.0103	0.0184	0.0465	0.0000

∑	∑/2	AI
0.4296	0.2148	0.7852

Appendix EE. AI Calculation CAPS – P1 March 2017.

Frequency matrices

CAPS			
34	14	36	0
2	2	2	0
16	8	23	0
5	6	1	0

Guidelines 2016			
24	16	43	0
2	3	1	0
12	8	18	0
3	4	1	0

CAPS 2016			
58	30	79	0
4	5	3	0
28	16	41	0
8	10	2	0

P1 March 2017			
5	3	14	0
6	1	1	0
8	3	11	0
3	0	2	0

Ratio matrices

CAPS 2016			
0.2042	0.1056	0.2782	0.0000
0.0141	0.0176	0.0106	0.0000
0.0986	0.0563	0.1444	0.0000
0.0282	0.0352	0.0070	0.0000

P1 March 2017			
0.0877	0.0526	0.2456	0.0000
0.1053	0.0175	0.0175	0.0000
0.1404	0.0526	0.1930	0.0000
0.0526	0.0000	0.0351	0.0000

Absolute differences ratio matrix and AI calculation.

ADM CAPS – P1 March 2017			
0.1165	0.0530	0.0326	0.0000
0.0912	0.0001	0.0070	0.0000
0.0418	0.0037	0.0486	0.0000
0.0245	0.0352	0.0280	0.0000

∑	∑/2	AI
0.4821	0.2410	0.7590

Appendix FF. AI Calculation CAPS – P1 November 2017

Frequency matrices

CAPS			
34	14	36	0
2	2	2	0
16	8	23	0
5	6	1	0

Guidelines 2017			
18	20	35	0
2	3	1	0
10	8	19	0
3	4	1	0

CAPS 2017			
52	34	71	0
4	5	3	0
26	16	42	0
8	10	2	0

P1 November 2017			
4	4	14	0
1	1	3	0
4	4	13	0
3	1	3	0

Ratio matrices

CAPS 2017			
0.1905	0.1245	0.2601	0.0000
0.0147	0.0183	0.0110	0.0000
0.0952	0.0586	0.1538	0.0000
0.0293	0.0366	0.0073	0.0000

P1 November 2017			
0.0714	0.0714	0.2500	0.0000
0.0179	0.0179	0.0536	0.0000
0.0714	0.0714	0.2321	0.0000
0.0536	0.0179	0.0536	0.0000

Absolute differences ratio matrix and AI calculation.

ADM CAPS – P1 November 2017			
0.1190	0.0531	0.0101	0.0000
0.0032	0.0005	0.0426	0.0000
0.0238	0.0128	0.0783	0.0000
0.0243	0.0188	0.0462	0.0000

$\sum$	$\sum/2$	AI
0.4327	0.2163	0.7837

Appendix GG. AI Calculation CAPS – P1 March 2018.

Frequency matrices

CAPS			
34	14	36	0
2	2	2	0
16	8	23	0
5	6	1	0

Guidelines 2017			
18	20	35	0
2	3	1	0
10	8	19	0
3	4	1	0

CAPS 2017			
52	34	71	0
4	5	3	0
26	16	42	0
8	10	2	0

P1 March 2018			
5	1	20	0
3	1	1	0
6	2	10	0
2	2	3	0

Ratio matrices

CAPS 2017			
0.1905	0.1245	0.2601	0.0000
0.0147	0.0183	0.0110	0.0000
0.0952	0.0586	0.1538	0.0000
0.0293	0.0366	0.0073	0.0000

P1 March 2018			
0.0877	0.0175	0.3509	0.0000
0.0526	0.0175	0.0175	0.0000
0.1053	0.0351	0.1754	0.0000
0.0351	0.0351	0.0526	0.0000

Absolute differences ratio matrix and AI calculation.

ADM CAPS – P1 March 2018			
0.1028	0.1070	0.0908	0.0000
0.0380	0.0008	0.0066	0.0000
0.0100	0.0235	0.0216	0.0000
0.0058	0.0015	0.0453	0.0000

∑	∑/2	AI
0.4536	0.2268	0.7732

CAPS Grade 12 Physics

49	2	0	0
0	31	3	0
0	4	60	0
0	0	0	0

Pr(a) 0.9396
Pr(e) 0.3508
K 0.9070

Guidelines 2014

36	0	0	0
2	32	0	0
0	0	56	0
0	0	0	0

Pr(a) 0.9841
Pr(e) 0.3522
K 0.9755

Guidelines 2015

38	0	0	0
0	34	0	0
0	1	58	0
0	0	0	0

Pr(a) 0.9924
Pr(e) 0.3529
K 0.9882

Guidelines 2016

39	0	0	0
1	29	1	0
0	1	62	0
0	0	0	0

Pr(a) 0.9774
Pr(e) 0.3651
K 0.9645

Guidelines 2017

30	0	0	0
1	34	0	0
1	2	52	0
0	0	0	0

Pr(a) 0.9667
Pr(e) 0.3528
K 0.9485

Guidelines 2014 – 2017

151	0	0	0
4	129	1	0
1	4	228	0
0	0	0	0

Pr(a) 0.9807
Pr(e) 0.3531
K 0.9702

P1 November 2014

17	1	0	0
0	8	2	0
0	3	26	0
0	0	0	0

Pr(a) 0.8947
Pr(e) 0.3810
K 0.8299

P1 March 2015

13	0	0	0
0	7	2	0
0	1	25	0
0	0	0	0

Pr(a) 0.9375
Pr(e) 0.4093
K 0.8942

P1 November 2015

10	1	0	0
1	4	2	0
2	2	28	0
0	0	0	0

Pr(a) 0.8400
Pr(e) 0.4608
K 0.7033

Kappa calculations continued…

P1 November 2017

12	0	0	0
2	7	1	0
0	4	29	0
0	0	0	0

Pr(a) 0.8727
Pr(e) 0.4192
K 0.7809

P1 March 2018

15	1	0	0
0	1	5	0
0	1	33	0
0	0	0	0

Pr(a) 0.8750
Pr(e) 0.4943
K 0.7528

P1 2014 – 2018

100	12	0	0
10	46	16	0
5	22	218	0
0	0	0	0

Pr(a) 0.8485
Pr(e) 0.4128
K 0.7420

P1 November 2017

12	0	0	0
2	7	1	0
0	4	29	0
0	0	0	0

Pr(a) 0.8727
Pr(e) 0.4192
K 0.7809

P1 March 2018

15	1	0	0
0	1	5	0
0	1	33	0
0	0	0	0

Pr(a) 0.8750
Pr(e) 0.4943
K 0.7528

P1 2014 – 2018

100	12	0	0
10	46	16	0
5	22	218	0
0	0	0	0

Pr(a) 0.8485
Pr(e) 0.4128
K 0.7420

Overall

300	14	0	0
14	206	20	0
6	30	506	0
0	0	0	0

Pr(a) 0.9234
Pr(e) 0.3709
K 0.8782

The Guidelines physics topic weighting is mark based. Table 101 shows the mark allocation of the P1 (November 2014 – March 2018) which was used to compare the physics topic weighting of the P1 to the Guidelines.

Appendix II. Physics Topic Weighting in the Guidelines and the P1.

Table 101

P1 November 2014 Mark Allocation by Physics Topic

Examination	PST1	PST2	PST3	PST4	Total marks
P1 November 2014	69	13	55	13	150
P1 March 2015	65	14	55	16	150
P1 November 2015	69	13	53	15	150
P1 March 2016	71	12	53	14	150
P1 November 2016	65	15	55	15	150
P1 March 2017	64	15	56	15	150
P1 November 2017	68	12	55	15	150
P1 March 2018	70	13	52	15	150
Total marks	541	107	434	118	1200
Percent	45	9	36	10	

Note. P1, National Senior Certificate Physical Sciences: Physics (P1) examination.

Table 102 shows that the physics topic weighting of the P1 is similar to the physics topic weighting described in the Guidelines. The differences that existed was due to the overemphasis of the mechanics topic at the expense of the waves, sound and light topic as well as the electricity and magnetism topic. The optical phenomena topic weighting in the P1 was the same as it was described in the Guidelines.

Table 102

P1 and Guidelines Physics Topic Weighting

Physics topic	PST code	P1 weighting	Guidelines weighting
Mechanics	1	45	42
Waves, sound and light	2	9	11
Electricity and magnetism	3	36	37
Optical phenomena	4	10	10

ATTACHMENTS

Editing Receipt.

Regent Research Writing Pvt Ltd

Receipt

Order #: 206534319656
Date: April 16, 2018
Time: 09:30:11 AM GMT

Billed To
Nishaal Bhaw
93 Winchester Drive
Reservoir Hills, Kwazulu Natal 4091
ZAF
0832865855

* **Billing Method:** Credit Card 527674********67

Ship To
(Not Available)

Order Summary #206534319656

Item	Unit Price	Subtotal
Regent Editing regentediting.co.za	[redacted]	[redacted]

*Depending on issuing bank, charges on statements should appear as "2CO.COM*ResearchW"
**All prices and totals are displayed as ZAR. This was the currency at the time of purchase.

[redacted]

Thank you for your business!

http://www.dissertationserviceuk.com has selected 2CO to process its payments.
For questions about your order, including product delivery questions, please contact Regent Research Writing Pvt Ltd (http://www.dissertationserviceuk.com).
To Manage your billing information, please visit www.2co.com

Turn it in Receipt.

Congratulations - your submission is complete! This is your digital receipt. You can print a copy of this receipt from within the Document Viewer.

Author:
Nishaal Bhaw

Assignment title:
Revision 1

Submission title:
The Alignment of the National Senior Certificate Examinations (November 2014 - March 2018) and the Curriculum and Assessment Policy Statement Grade 12 Physical Sciences: Physics (P1) in South Africa

File name:
55497551 MSc Physics Education.pdf

File size:
2.3M

Page count:
245

Word count:
55584

Character count:
292687

Submission date:
22-May-2018 10:59AM (UTC+0200)

Submission ID:
967094623

« Page 1 »

The Alignment of the National Senior Certificate Examinations (November 2014 - March 2018) and the Curriculum and Assessment Policy Statement Grade 12 Physical Sciences: Physics (P1) in South Africa

by

Nishaal Bhaw

submitted in accordance with the requirements for

the degree of

MASTER OF SCIENCE IN MATHEMATICS, SCIENCE AND TECHNOLOGY EDUCATION

in the subject

PHYSICS EDUCATION

at the

UNIVERSITY OF SOUTH AFRICA

SUPERVISOR: PROF J. KRIEK

June 2018