UNIVERSITY OF PRETORIA

NAME OF THE SCHOOL

NAME OF THE DEPARTMENT

STUDY MANUAL

MODULE NAME AND CODE

MODULE WEBSITE ADDRESS:
Website address

Compiled by:
Name

Date of last revision:
Date

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ORGANISATIONAL COMPONENT

1. GENERAL PREMISE AND EDUCATIONAL APPROACH

Example: *(from Materials Science NMC 122)*
The general objective with this module is to emphasise ***understanding*** *rather than memorising, in order to stimulate* ***creative thinking*** *and the development of* ***innovative skills*** *amongst students in the field of materials science and materials engineering. A problem-driven approach to learning is followed. Student-centred and co-operative learning and teaching methods are applied during lectures, tutorial classes and practicals, in order to optimally develop the above skills, as well as to stimulate the development of communication skills, interpersonal skills and group dynamics.*

You are expected to participate in discussions during lectures and tutor classes. As your fellow students are dependent on the inputs you make, your participation is crucial. After all, you are also dependent on their contributions.

The effective use and application of engineering materials are essential to the practice of all engineering disciplines. In the study of this module, skills are developed which will enable the learner to understand the fundamentals that govern the particular properties and behaviour of materials; to determine the properties of materials by various testing methods; to select suitable materials for particular engineering applications; to solve materials-related problems such as ways to prevent failure of structural components.

Example: *(from Construction KON 110)*
In terms of the educational policy of the University it is accepted that "a student should undergo an academic-scientific moulding as to be able later in professional context to function as an independent scientist and to contribute to the creative development of the chosen profession . . . in effect it refers to a purposeful and pro-active education approach which brings with it a change in emphasis from the traditional lecturer-centred teaching approach to a more dynamic student-centred learning approach." (A new approach, Tukkie-onderrig, Vol. 1(2), 1986). A syllabus for this module has accordingly been developed as worded in this study guide.

2. LECTURERS, VENUES AND CONSULTING HOURS

	Name	**Room No. and Building**	**Telephone No. and E-mail Address**
Lecturers			
Module Manager			
Lecturer Group A			
Lecturer Group B			
Lecturer Group C			
Lab. Instructor			
Tutors			

Teaching Assistants			
Secretary			
Class Mates			

Location of the Laboratory:

Location of the Notice Board:

Consulting hours:

Example: *(from Electrical, Electronic and Computer Engineering, as adapted)*
Hours for consultation of lecturers, tutors and teaching assistants will be announced at the beginning of the semester, and will also be displayed on their office doors. Students may consult lecturers, tutors and teaching assistants only during the consulting hours as indicated, or by appointment. This policy also holds before tests and exams. In other words, lecturers, tutors and teaching assistants are only available during their normal consulting hours on the day before a test or examination. This policy aims to encourage students to plan their work and to work continuously.

3. STUDY MATERIALS AND PURCHASES

Guideline:
References to the prescribed textbook and other general prescribed study material such as books for further reading, subject periodicals, class notes, calculators, software and internet references should be given here. References that are applicable only to some specific study themes and that need not be purchased in advance, should rather be given in the "study component" section of the study guide under the heading of the particular study theme. Throughout, a distinction should be made between compulsory prescribed items to be purchased, and supplementary items which can be accessed through the library, internet, etc.

Example: *(from Materials Science NMC 122)*
Prescribed text book: William F Smith, Principles of Materials Science and Engineering, Third Edition, McGraw-Hill, 1995. This book will be used extensively and it is compulsory that each student obtain a copy.

Class notebook: A notebook containing copies of all the slides presented at the lectures is handed to each student at the first lecture. In the notebook, space is also provided for brief notes and specific references to the textbook during the lectures. The cost of the notebook is included in your module tuition fee.

A set of the slides presented during the lectures, as well as other relevant study materials, is also available on the module website.

4. LEARNING ACTIVITIES

4.1 Contact time and learning hours

Example: *(from Materials Science NMC 122)*
Number of lectures per week: four
Number of tutor classes per week: one
(One additional tutor class per week is presented to students on the five-year programme.)
Laboratory work: Four experiments of three hours each..

This module carries a weighting of 16 credits, indicating that on average a student should spend some 160 hours to master the required skills (including time for preparation for tests and examinations). This means that on average you should devote some 10 hours of study time per week to this module. The scheduled contact time is approximately five hours per week, which means that another five hours per week of own study time should be devoted to the module.

4.2 Lectures

Example: *(from Materials Science NMC 122)*
Lectures are presented in a style of co-operative and student-centred learning. Brief clarification and explanation of the subject matter and concepts are given during the lectures. Problems related to the subject matter are posed and students are expected to attempt the problems in groups of three to four persons, which is followed up by class discussions. Students are advised not to take comprehensive notes during lectures. The time should rather be used more effectively by concentrating on the lecturing and by active participation in discussions. All the relevant study material is adequately referenced and is available in the textbook, the notebook, the study guide and on the module website.

4.3 Tutorial classes

Example: *(from Materials Science NMC 122)*
Five class periods per week are provided for in the timetable. The first four are allocated to lectures, whilst the last (fifth) period each week is allocated as a tutorial class. During each tutorial class, problems and exercises related to the current work dealt with in the lectures are handed out and students are requested to attempt these in small groups of three or four persons per group. Active participation from each student in a group is mandatory. The lecturer and the teaching assistant will be available for consultation by and assistance to students during tutor classes. At the conclusion of certain of the tutorial classes, a small test related to the contents of the work is written. The test marks will be incorporated in the semester mark.

One additional tutorial class per week is offered to all the students on the five-year programme. ***Attendance of these tutorial classes is compulsory for all students registered on the five-year programme. A time table will be supplied and will be posted on the Materials Science notice board*** *During these tutorial sessions, an experienced tutor will be available to assist students personally with problems experienced with work which is currently dealt with in the lectures. Students are also required to attempt to solve problems related to the current work dealt with in the lectures. Students will be divided into three groups and a tutor will be allocated to each group. Co-operative learning techniques will be applied and students are required to work in small groups of three or four persons per group. Active participation from each student in a group is mandatory. At the conclusion of certain of the tutorial classes a small test related to the contents of the work is written. From time to time, homework assignments will be given, which must be submitted at the next tutor class for marking. The marks obtained for the tests and the assignments will be incorporated in the semester mark. Apart from the formal tutorial sessions, tutors will also be available for consultation by appointment.*

4.4 Assignments

Example: *(from Materials Science NMC 122)*
Five assignments, containing problems and exercises related to the subject matter, are given on the module website. Hard copies of the assignments can also be obtained at the office of the lecturer. It is compulsory for students on the ***four-year programme*** *to submit the completed assignments during lectures on the set date as indicated on each assignment. No late submissions will be accepted. After marking, the assignments will be handed back to students. The marks obtained are incorporated in the semester mark.*

4.5 Laboratory work

Example: *(from Materials Science NMC 122)*

Laboratory groups and sessions *Students will be allocated to nine groups and their group allocation will be displayed on the Materials Science notice board. The onus is on each student to find out his/her particular group allocation. Each week, four or five laboratory sessions are presented and it takes two weeks to complete an experiment with all the students. This means that on average a student reports for a practical only once every fortnight. A timetable that must be consulted is posted on the Materials Science notice board and is also available on the module website. Each student must perform a total of four experiments. Students report at the Materials Science Laboratory (Room 4-5, Mineraalwetenskappe building).*

Exchange of laboratory sessions. *If it is impossible to attend the laboratory session in the allocated period, alternative arrangements must be made. Consult Mr J W Borman (Office 4-3) in this regard.*

Rules and requirements *An additional requirement for a pass in this module is a subminimum of 50% for the laboratory work and attendance of all four scheduled laboratory sessions. The laboratory mark is compiled from the laboratory report plus the laboratory test. Furthermore, the laboratory mark accounts for 15% of the semester mark.*

A group of approximately six students will work together on an experiment during a laboratory session. Students must be well prepared when reporting for a laboratory session. Upon arrival a pre-report must be submitted by each student. It must contain in the students' own words, a brief description of the purpose of the experiment and how it is going to be achieved. It is unacceptable to merely copy the "objective" and the "experimental method" from the Laboratory Instructions. Before writing the prereport, the relevant chapter in the prescribed textbook and also the issued ***Laboratory Instructions*** *must be consulted.*

During laboratory sessions, the work must be well organised by students within each group, in order to complete the work in the most efficient manner. A "report sheet" will be handed to each student, on which the experimental results must be tabulated and presented graphically, etc. Under the heading "discussion", each student is expected to briefly describe in his/her own words the basic principles illustrated in the experiment.

At the end of the laboratory session, each student must hand the complete report sheet to the supervising person, before leaving the laboratory. A short test will also be written at the end of the session. Both the report and the test will be assessed.

4.6 Projects

Example: *(from Innovation ENV 110)*

Semester Project

Expected outcome *Students should be able to demonstrate technological innovation to a real product, through the application of relevant knowledge and skills. This must be done through co-operation in teams.*

Assignment *Students will work in teams of three to develop, document, present and demonstrate a technological innovation which comprises one of the following:*
1. An educational device or toy for a child under the age of seven.
2. A rehabilitation or convenience aid for an aged or physically handicapped person.
The students may use any resources available.

Teams *Students must work in teams of three persons for the practical sessions conducted in the laboratory and for the development of the semester project. The same team members will work together on the semester project for Information Technology EIT110. Students must choose their own team members. Each student will have the opportunity to have his brain dominance determined. Teams must preferably comprise members with different and thus complementary brain dominance. Each design team must make up a name for the fictitious company to which they belong. The design of a company logo will form part of the semester project for Information Technology EIT110. Students who have not formed a team by the first test week will be assigned to a team by the lecturer. Any changes to the members of the group or the name of the team must be requested in writing or by e-mail to the module lecturers with a substantiation of the request. Written approval by the module lecturers is required for all such changes.*

Prototype *The prototype of the device must be constructed by the students. It may not be an existing, commercially available product, although it might be a similar, but clearly improved version of the existing product. The use of electronic kits or designs taken from hobby journals are acceptable, provided that they form part of a novel product which solves a real problem. The prototype or model of the product must be complete, including packaging, technical specifications, warranty, and instructions for use, where applicable. The following are excluded and are not acceptable as semester projects: Software only, board games (such as Monopoly or Pictionary), hardwired electrical problem-answer-boards.*

Cost *The cost of the components, construction, and packaging of the prototype will be paid by the members of the team and may not exceed R150. The prototype of the product will remain the property of the team.*

Laboratory books *Laboratory notebooks are compulsory for all modules that include practical work. Each student of the team must acquire an A4 size hard-cover notebook, in which complete dated notes and sketches are kept showing the development of the product, including user surveys, preliminary designs, experiments done in the laboratory, design evaluations, and technical details of the design. Details of how a laboratory notebook should be kept are given in the EEC Guide. The lecturers may evaluate the laboratory notebook at any time .*

Presentation *A three-minute presentation of which each of the group members will present one minute will be required during the demonstration of the semester project at the end of the semester. Project demonstrations will take place in the laboratory at scheduled time and also during the class periods in the week before the examination.*

Assessment criteria
The criteria for assessing presentations as follows: Appearance of group, coherence of presentation, clarity of presentation, is it clear what the real problem is that the group has addressed?, is the presentation convincing?, are the benefits of the product well presented?, is the operation of the

product clearly explained?, how well did they plan their time for the presentation?, how well did they use audiovisual aids in their presentation?, how well did they answer questions?, how well did they co-operate in their presentation?, command of language.

Criteria for the assessment of the product include the following: Functionality (how well does it solve a real problem?, how well does it work or can it work?), Completion (how well is the product/prototype/model finished?, how much detail have been considered in the finishing/packaging of the product ?), Novelty (to what extent is it new or an improvement on existing products?).

Disclosure *Presentation of the product for module assessment will not constitute public disclosure, hence students may apply for a patent on the product.*

Report *Each group must produce a printed project report which briefly documents the aspects listed in the table below in either Afrikaans or English. The pages of the report must be bound together using staples, ring binder, or otherwise. The report or individual pages of the report may not be submitted in plastic file bags. A copy of the project report must be personally handed in at Engineering Building room 14-6 before 08:00 on Friday, 26 May 2000. A receipt will be issued for the project report, which must be kept by one of the students in case of a dispute over the handing-in of the report.*

Requirements for the Project Report on the Semester Project for Innovation ENV110

Section	***Contents***
Title page	*Department name, module title, group name, project title, author(s), date, group members (names, student numbers, programme (electrical, electronic, computers, and where applicable team roles or individual contributions)*
Table of contents	*Table of contents with page numbers.*
Product description	*Brief description of the product and its application.*
Problem analysis	*Identification of the problem or opportunity, customer needs, market survey and customer input, positive problem definition statement.*
Design context	*Social, cultural, environmental, ethical, legal, safety, economics and other relevant contexts which have been considered in the design of the product.*
Design objectives	*Criteria to be satisfied by the final product.*
Design concepts	*A brief description of at least two concepts or ideas which were considered as solutions for the chosen problem.*
Design optimisation	*How the ideas were refined and the criteria by which the best concept was selected.*
Design detail	*Drawings and specifications of implementation including sketches and drawings from the inventor's logbooks of your group.*
Benefits	*Value to the customer and alternative uses if applicable.*
Instruction manual	*Operation, safety precautions, guarantees and reference information.*
Price and marketing	*Component price, manufacturing price, selling price, selling plan.*
Resources	*References to books and articles, names of persons and institutions consulted, details of suppliers of project materials*

Section	***Contents***
Personal highlights	*Knowledge and skills acquired by doing the project, personal comments of individual group members on the project and the experience.*

5. RULES OF ASSESSMENT

Also see the examination regulations in the Year Books of the Faculty of Engineering, Built Environment and Information Technology (Part 1: Engineering, or Part 2: Built Environment and Information Technology).

Guideline 1: *In terms of the new examinations regulations of the University and of the Faculty, the pass requirements, the formula for calculation of the semester/year mark and of the final mark, as well as certain special requirements (practicals, subminima and promotion requirements), must be clearly specified. This information will be published per semester in a schedule, along with those of all the other modules presented in each school, for approval by the Dean. This information for the particular module must also be included in the study manual. Consult the examination regulations for full details.*

Guideline 2: *A semester test of an eight-credit module should not take longer than 45 minutes and a 16-credit module should not take longer than 90 minutes. A final examination of an eight-credit module should not take longer than 90 minutes and a 16-credit module not longer than 180 minutes.*

Example: *(from Materials Science NMC 122)*

Pass requirements *In order to pass the module a student must*
1 obtain a final mark of at least 50%.
and
2. obtain a subminimum of 50% for the laboratory work and also attend all four scheduled laboratory sessions.
If a student obtained a final mark of 50% or more but does not meet the laboratory requirements, the laboratory work must be repeated successfully before a pass will be awarded.

Calculation of the final mark *The final mark is calculated as follows:*

Semester mark:	*50%*
Examination mark:	*50% (The final examination takes three hours.)*

Calculation of the semester mark *The semester mark is compiled as follows:*

Semester tests:	*60%*
Laboratory work:	*15%*
Tutor class tests	*15%*
Assignments	*10% (four-year programme students only)*
Tutor class work	*10% (five-year programme students only)*

Semester tests. *Two tests of 90 minutes each will be written during the scheduled test weeks of the School of Engineering:*

First test week:
Second test week:

Dates, times and venues will be announced as soon as the timetables become available.

Any **absence** *from semester tests must be supported by an official and valid statement (e.g. a medical certificate) and must be submitted to the lecturer within three days of the date of the test. A special* *semester test for all legitimate absentees can be taken on the first Saturday following the second test week. This test will be based on all the work done in the module thus far.*

6. GENERAL

Guideline: *Policies, rules and arrangements regarding the following should be given in this section:*

Late assignments and reports
Conduct in class
Grievance procedures
Academic dishonesty
Absence from certain scheduled activities
Dress code (e.g. safety clothing for laboratory work)
Pocket calculator specifications
Posting of official notices

STUDY COMPONENT

1. MODULE OBJECTIVES, ARTICULATION AND LEARNING OUTCOMES

Guidelines:
The following information must be given in this section:
1. A summary of the general objectives with the module.
2. A statement reflecting the prerequisite learning assumed to be in place.
3. A diagram or statement indicating how this module articulates with and relates to other modules in the programme
4. Statements of the critical exit-level learning outcomes to be achieved in the module and an explanation of how these outcomes will be achieved in the context of the particular nature, learning activities and contents of the module. The module represents one building block in the whole programme, but it is an integrated part of the whole and should therefore make a definite contribution to the achievement of a set of defined exit-level outcomes. It should contribute to the achievement of some of the exit-level outcomes of the programme, but is unlikely to address them all -. A list and explanation of the exit-level outcomes required by the Engineering Council of South Africa (ECSA) for the engineering bachelor's degrees are given in the Appendix. A list of the exit-level outcomes of other degree programmes can be obtained from their SAQA registration documentation.

1.1 General objectives

Example: *(from Materials Science NMC 122)*
The effective use and application of engineering materials are essential to the practice of all engineering disciplines. In the study of this module, skills are developed which will enable the learner to:

- *understand the fundamentals governing the particular properties and behaviour of materials;*
- *determine the properties of materials through various testing methods;*
- *select suitable materials for particular engineering applications;*
- *solve materials-related problems such as ways to prevent failure of structural components.*

The general objective with this module is to emphasise ***understanding*** *rather than memorising, in order to stimulate* ***creative thinking*** *and the development of* ***innovative skills*** *amongst students in the field of materials science and materials engineering. A problem-driven approach to learning is followed. Student-centred and co-operative learning and teaching methods are applied during lectures, tutorial classes and practicals, in order to optimally develop the above skills, as well as to stimulate the development of communication and interpersonal skills and group dynamics.*

In order to achieve the objectives, attendance of and meaningful participation during lectures, laboratory sessions and tutor classes is essential. Furthermore, students are advised to embark on a well-structured and systematic study programme, in which the module material is studied in a probing, scientific and innovative manner, rather than by simple and passive memorising. On average, about five hours' own study time per week should be devoted to the module.

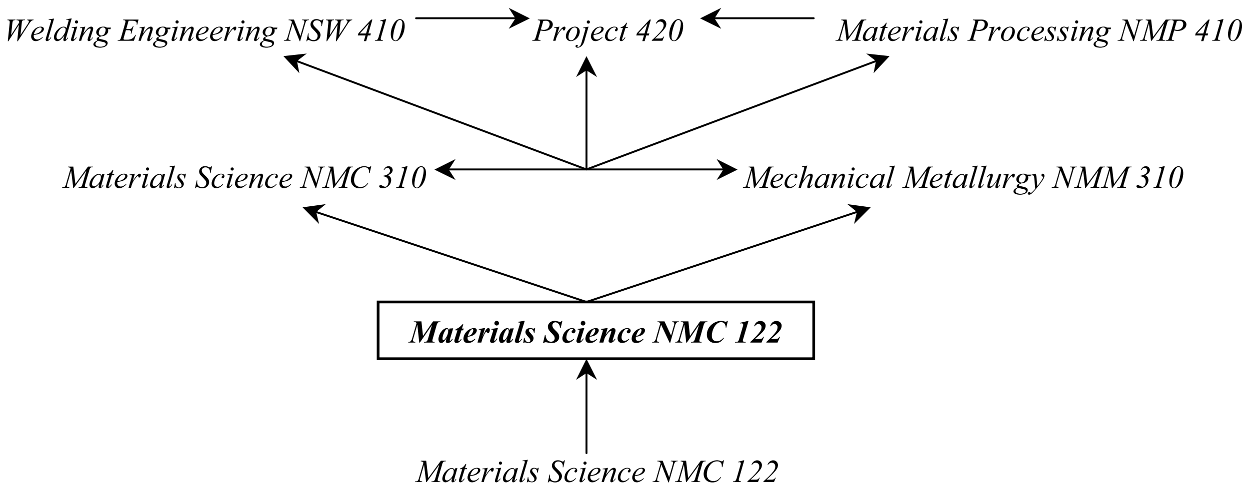
1.2 Prerequisite learning

Example: *(from Materials Science NMC 221)*
Before admission to this module, a student must pass the Materials Science NMC 122 module. At the beginning of the semester, a short revision test on certain aspects of NMC 122 will be taken. Further details of the scope and date of the test will be given in class. Students are also advised to revise

certain sections of first-year chemistry, in particular those on atomic structure and bonding; behaviour of gases, liquids and solids; and the chemistry of the main group transition elements.

1.3 Articulation with other modules in the programme

Example: *(from Materials Science NMC 221)*



1.4 Critical learning outcomes

Example: *(from Materials Science NMC 122)*

The following ECSA exit-level outcomes are addressed in the module, i.e. at the conclusion of this module the student will be capable of:

ECSA 2.1: ***Engineering problem solving***
To creatively and scientifically solve simple real world materials-related engineering problems, such as materials selection for specific applications and failure analysis of structural components.

ECSA 2.2: ***Application of fundamental and scientific knowledge***
The application of fundamental principles and concepts of physics and chemistry to predict the behaviour and the properties of materials, and to understand the relationship between the internal structure of materials and their resultant properties. The calculation, interpretation and application of a variety of mechanical, electrical, magnetic and corrosion properties of materials.

ECSA 2.4: ***Investigations, experiments and data analysis***
To conduct materials testing experiments by using appropriate equipment, to calculate and predict materials properties from the acquired experimental data, and to critically analyse, interpret and present the results. To prepare a scientific-technical report on the findings.

ECSA 2.8 ***Team and multidisciplinary work***
It is required from students to work in groups and teams during laboratory sessions and tutor classes in an effective and structured manner, which contributes to the development of certain interpersonal and communication skills.

ECSA 2.9 ***Lifelong learning***
The development of learning skills, such as understanding fundamental concepts, scientific logic and reason, and the extensive use of the prescribed text book in their studies are emphasised in this module, which facilitates a capacity for lifelong learning.

1.5 Cognitive level of assessment

Guideline 1: *See paragraph 3.5 below for an explanation of Bloom's classification of lower and higher order thinking skills and apply this concept to the specific module, in terms of the required level(s) of thinking skills that must be attained by the student in the specific module.*

Guideline 2: *Give an estimate of the % of the total assessment, including all forms of assessment applied in this module, devoted to the various levels of cognitive thinking skills, and of the development of "other skills". Also specify the "other skills". Typically, on the first year level, a higher proportion of the assessment is aimed at the lower cognitive thinking levels of* ***knowledge****,* ***comprehension*** *and* ***application****, but it should also include assessment of some higher cognitive thinking levels. Typically, assessment of the higher cognitive thinking levels of* ***analysis, synthesis*** *and* ***evaluation*** *is gradually increased in modules of the second, third and final years*

Example :1 *(from Innovation NNV 110)*

	%*
1. Knowledge	20
2. Comprehension	20
3. Application	20
4. Analysis	10
5. Synthesis	10
6. Evaluation	5
7. Other skills**	15

* Estimate of the % of the total assessment, including all forms of assessment applied in this module, devoted to the various levels of cognitive thinking skills and of "other skills".

** Assessment of "other skills":
Presentation skills √
Report writing and language skills √
Practical skills √
Team working skills √

Example 2: *(from Project NSC 400)*

	%*
1. Knowledge	5
2. Comprehension	5
3. Application	5
4. Analysis	15
5. Synthesis	20
6. Evaluation	20
7. Other skills**	30

* Estimate of the % of the total assessment, including all forms of assessment applied in this module, devoted to the various levels of cognitive thinking skills and of "other skills".

** Assessment of "other skills":
Presentation skills √
Report writing and language skills √
Practical skills √
Team working skills

2. MODULE STRUCTURE

Example: *(from Materials Science NMC 122)*

Study theme and Study units	***Mode of instruction***	***Notional hours***	***Contact sessions***
1. Introduction and fundamental principles 1.1 Materials science and engineering 1.2 Atomic structure and bonding	*Class discussion, tutor class and self-study*	*8*	*4*
2. Crystal structures and geometry 2.1 Types of crystal structure 2.2 Directions and planes 2.3 Density calculations 2.4 Polymorphism	*Lectures and class discussion, tutor classes, assignment*	*16*	*6*
3. Solidification, crystalline imperfections and diffusion 3.1 Solidification 3.2 Crystalline imperfections 3.3 Diffusion in solids	*Lectures and class discussion, tutor classes, assignment*	*24*	*10*
4 Electrical properties of materials 4.1 Introduction and theories of conduction 4.2 Electrical properties of ceramics 4.3 Semiconductors	*Lectures and class discussion, tutor classes, assignment*	*24*	*10*
5. Mechanical properties of materials 5.1 Processing of metals 5.2 Stress and strain in materials 5.3 Mechanical properties and testing 5.4 Plastic distortion, cold work and recrystallisation	*Lectures and class discussion, tutor classes, assignment*	*28*	*12*
6. Magnetic properties of materials (To be completed)	*(To be completed)*	*16*	*6*
7. Polymeric materials (To be completed)	*(To be completed)*	*16*	*6*
8. Corrosion of metals (To be completed)	*(To be completed)*	*16*	*6*
9. Laboratory work Four experiments, see the Laboratory Instructions booklet	*Experimental work in small groups, individual reports*	*16*	*4x4*
	Total	***164***	***76***

Note: *The notional hours include the contact time, as well as the estimated time to be allocated for self-study, preparation of assignments and preparation for tests and the examination.*

3. GUIDELINES FOR USING THE STUDY THEME DESCRIPTIONS

The information given in the next sections of this study manual under the various study theme headings is intended to assist students in their learning, in order to acquire the required skills and achieve the learning outcomes effectively. The following specific informational items are included under each of the study theme headings:

3.1 Learning outcomes of the study theme

The given learning outcomes for each study theme are essential to achieve the critical learning outcomes as set out in Section 1.4.

3.2 Study units

The title of the study unit and references to appropriate study material are given here. The study of the referenced study material is regarded as the minimum required to achieve the learning outcomes satisfactorily.

3.3 Self-study activities

Here information is given about exercises and problems related to the study material, which should be attempted and which are in accordance with the criteria of assessment of the study theme.

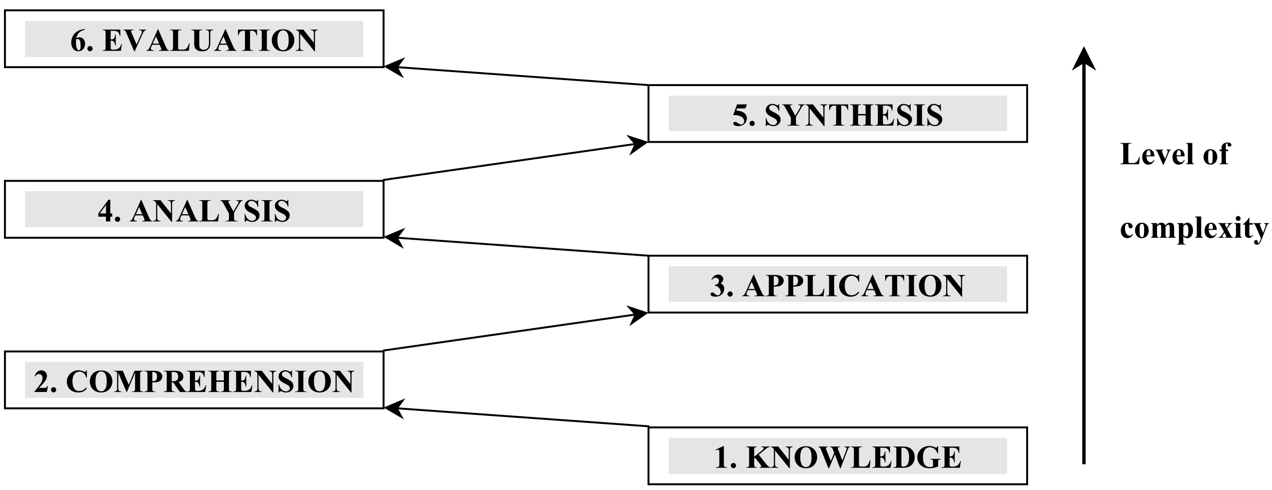
3.4 Assignments for assessment

Here information is given about assignments to be submitted for marking and assessment.

3.5 Criteria of assessment

The criteria of assessment are a list of specific skills to be mastered by the student in order to achieve the learning outcomes of the syllabus theme. During assessment (tests and the examination), students will be evaluated in terms of these criteria.

The statements used to define the criteria of assessment are classified in terms of a series of lower- to higher-order thinking skills (cognitive domains), in accordance with Bloom's *Taxonomy of Educational Objectives* (Bloom BS and Krathwohl DR, *Taxonomy of educational objectives. Handbook 1. Cognitive domain,* Addison-Wesley, 1984):



The characterisation of the cognitive domains is given in the table below.

	Cognitive Domain	Definition	Typical Action Verbs
1.	Knowledge	Remembering previously learned information.	Arrange, define, describe, identify, label, list, match, name, outline
2.	Comprehension	Understanding the meaning of information.	Classify, discuss, estimate, explain, give example(s), identify, predict, report, review, select, summarise, interpret, "in your own words"
3.	Application	Using the information appropriately in different situations	Apply, calculate, demonstrate, illustrate, interpret, modify, predict, prepare, produce, solve, use, manipulate, put into practice
4.	Analysis	Breaking down the information into the component parts and seeing the relationships.	Analise, appraise, calculate, compare, criticise, derive, differentiate, choose, distinguish, examine, subdivide, organise, deduce
5.	Synthesis	Putting the component parts together to form new products and ideas.	Assemble, compose, construct, create, design, determine, develop, devise, formulate, propose, synthesise, plan, discuss, support
6.	Evaluation	Making judgments of an idea, theory, opinion, etc., based on criteria.	Appraise, assess, compare, conclude, defend, determine, evaluate, judge, justify, optimise, predict, criticise

The list of criteria of assessment for a study theme and its accompanying envisaged learning outcomes should contain statements applicable to all six levels of thinking. Accordingly, students will be evaluated in terms of a mix of all six levels of thinking skills. On the first-year level, a larger proportion of questions will be based on the lower levels (levels 1 to 3), whilst final-year examinations will contain a larger proportion of questions based on the higher-level thinking skills (levels 4 to 6).

Guideline:
The information given above in 3.1 to 3.5 must be included in all study guides, but could be adjusted to suit the specific requirements of a particular module.
The following reference may also be consulted: Felder RM and Brent R, Effective teaching: a workshop, University of the Witwatersrand, 1996 and 1999, Workshop notes: Section B.

4. STUDY THEME DESCRIPTIONS

Guideline:
The separate Study Theme Sections need not to be bound into the Study Manual booklet, but could be handed to students in the period during the semester when the particular study theme is being dealt with. This should ensure that students use this information more efficiently.

Example of the description of a study theme: *(from Materials Science 122)*

4.4 STUDY THEME 4: Electrical Properties of Materials

4.4.1 Learning outcomes

At the end of this study theme, the student will:

- *have **knowledge** and **understanding** of the effect of changes in the internal structure, chemical composition and temperature on the electrical properties of materials and be able to **apply** this knowledge to specific situations.*
- *have **knowledge** and **understanding** of the various electrical properties of materials and of the three main types of electrical material (insulators, semiconductors and conductors).*
- *be able to **derive** materials-related mathematical expressions for a number of electrical properties.*
- *be able to **calculate** and **predict** the electrical properties of a given material from fundamental principles and to **select** appropriate electrical materials for specific applications.*

4.4.2 Study units

<u>Introduction to the electrical properties of materials and to the theories of conduction</u>
Smith, Chapter 5, §5.1 and 5.2

<u>The electrical properties of ceramics</u>
Smith, Chapter 10, §10.6

<u>Semiconductors</u>
Smith, Chapter 5, §5.3 and 5.4

4.4.3 Self-study activities

<u>Exercises:</u> Smith, Chapter 5, Problems nos 5.1.1, 5.1.3, 5.1.4, 5.1.13, 5.1.15, 5.2.4, 5.3.1, 5.3.3, 5.3.9, 5.3.10, 5.4.1, 5.4.2, 5.4 7, 5.4.12
Smith, Chapter 10, Problems nos 10.6.1 to 10.6.4, 10.6.7, 10.6.18, 10.6.19, 10.6.20.

4.4.4 Assignments for assessment

An assignment with problems based on this study theme is available on the module website. Hard copies can also be collected at the lecturer's office. The date of submission will be announced in class and is also given on the assignment sheet.

4.4.5 Criteria of assessment

At the end of this study theme, a student will be able to:

- ***formulate** the relevant definitions of the terms listed at the end of Chapters 5 and 10 of the prescribed textbook.*

- ***relate*** *examples of typical practical applications of conductors, semiconductors and insulators.*
- ***explain*** *why electrical resistance (R) is not a materials property, whilst resistivity and conductivity are considered as materials properties.*
- ***explain and indicate*** *the similarity between the microscopic form of Ohm's law and Fick's first law of diffusion..*
- ***calculate*** *the resistivity of a material at a specific temperature if its temperature resistivity coefficient is given. (See Example. Problem 5.3)*
- ***predict*** *the effect of impurities and alloying elements on the resistivity and the conductivity of a conductor such as copper, by application of data such as those given in Figs. 5.8 and 5.9.*
- ***explain*** *why the resistivity of a conductor such as copper is increased by: (1) an increase of the temperature, (2) the addition of alloying elements and (3) cold working, such as wire drawing.*
- ***apply*** *the energy-band model to* ***motivate*** *why some elements are good conductors and why others are poor conductors of electricity.*
- ***define*** *the dielectric constant of a material and* ***explain*** *the significance of this materials property for the selection of suitable materials as inserts for capacitors.*
- ***define*** *the dielectric strength of a material and* ***explain*** *the significance of this materials property for the selection of suitable materials as electrical insulators.*
- ***motivate*** *why electrical porcelain is used as insulators on high-voltage power transmission lines and why* $BaTiO_3$*-based materials are used as inserts for capacitors. (See also Tables 10.7 and 10.8)*
- ***calculate*** *the area of the capacitor plates if the dielectric constant of the insert material is given and if the electrical requirements of the capacitor are known.*
- ***select*** *by calculation and/or data appropriate materials for use as insulators or capacitor inserts for specific applications.*
- ***explain*** *the mechanism by which electrical conduction occurs in intrinsic semiconductors such as silicon and germanium.*
- ***derive*** *an expression for the conductivity of an intrinsic semiconductor.*
- ***calculate*** *the resistivity and the conductivity of intrinsic semiconductors. (See Example. Pr. 5.6)*
- ***explain*** *why the conductivity of semiconductors is increased by an increase in the temperature, whilst the conductivity of good conductors is decreased by an increase of the temperature.*
- ***explain*** *by using a typical example of each, the difference in the mechanism of electrical conduction between n-type extrinsic semiconductors and p-type extrinsic semiconductors.*
- ***derive*** *expressions for the conductivity of n-type and p-type extrinsic semiconductors.*
- ***calculate*** *the resistivity and the conductivity of extrinsic semiconductors. (See Example. Problems. 5.7 and 5.8)*

This study manual template were prepared by Gert Pienaar and Dolf Steyn, in co-operation with the members of the Committee for Education Innovation and Quality Control of the Faculty of Engineering, Built Environment and Information Technology.

APPENDIX

EXIT-LEVEL OUTCOMES FOR ENGINEERING BACHELOR'S DEGREES

(Excerpt from ECSA Document No. PE-61: *Standards for Accredited University Bachelor's Degrees)*

Required Outcomes:

"The required outcomes of an accredited university bachelor's degree in engineering are defined in Sections 2.1 to 2.10.

2.1 Engineering Problem Solving
The B.Eng./B.Sc.(Eng.) graduate is competent to
Identify, assess, formulate and solve convergent and divergent engineering problems creatively and innovatively.

2.2 Application of fundamental and specialist knowledge
The B.Eng./B.Sc.(Eng.) graduate is competent to
Apply knowledge of mathematics, basic science and engineering sciences from first principles to solve engineering problems, involving the following performances:

1. Bring mathematical, numerical analysis and statistical knowledge and methods to bear on engineering problems by using an appropriate mix of:
    a) Formal analysis and modelling of engineering components, systems or processes;
    b) Communicating concepts, ideas and theories with the aid of mathematics;
    c) Reasoning about and conceptualising engineering components, systems or processes using mathematical concepts;
    d) Dealing with uncertainty and risk through the use of probability and statistics.
2. Use physical laws and knowledge of the physical world as a foundation for the engineering sciences and the solution of engineering problems by an appropriate mix of:
    a) Formal analysis and modelling of engineering components, systems or processes using principles and knowledge of the basic sciences;
    b) Reasoning about and conceptualising engineering problems, components, systems or processes using principles of the basic sciences.
3. Use the techniques, principles and laws of engineering science at a fundamental level and in at least one specialist area to:
    a) identify and solve open-ended engineering problems;
    b) identify and pursue engineering applications;
    c) work across engineering disciplinary boundaries through cross disciplinary literacy and shared fundamental knowledge.

2.3 Engineering Design and Synthesis
The B.Eng./B.Sc.(Eng.) graduate is competent to
Perform creative, procedural and non-procedural design and synthesis of components, systems, works, products or processes, involving the performances:

1. *identify and formulate the design problem* to satisfy user needs, applicable standards, codes of practice and legislation;
2. *plan and manage the design process*: focus on important issues, recognise and deal with constraints;
3. *acquire and evaluate the requisite knowledge, information and resources:* apply correct principles, evaluate and use design tools;
4. *perform design tasks* including analysis, quantitative modelling and optimisation;
5. *evaluate alternatives and preferred solution*: exercise judgement, test implementability and perform techno-economic analyses;
6. *assess impacts and benefits of the design*: social, legal, health, safety, and environmental
7. *communicate the design logic and information*.

2.4 Investigations, experiments and data analysis
The B.Eng./B.Sc.(Eng.) graduate is competent to
1. Apply research methods.
2. Plan and conduct investigations and experiments using appropriate equipment.
3. Analyse, interpret and derive information from data.

2.5 Engineering methods, skills, tools and information technology
The B.Eng./B.Sc.(Eng.) graduate is competent to
1. Use appropriate engineering methods, skills and tools and assess the results they yield.
2. Use computer packages for computation, modelling, simulation, and information handling, involving:
    a) assessment of the applicability and limitations of the package;
    b) proper application and operation of the package;
    c) critical testing and assessment of the end-results produced by the package.
3. Use computers and networks and information infrastructures for accessing, processing, managing, and storing information to enhance personal productivity and teamwork.
4. Create computer applications as required by the discipline.
5. Bring basic techniques and knowledge to bear on engineering practice from economics, business management, and health, safety and environmental protection.

2.6 Professional and General Communication
The B.Eng./B.Sc.(Eng.) graduate is competent to
1. Communicate effectively, both orally and in writing, with engineering audiences and the community at large, using appropriate structure, style and graphical support;
2. Apply methods of providing information for use by others involved in engineering activity.

2.7 Impact of engineering activity on society and the environment
The B.Eng./B.Sc.(Eng.) graduate is critically aware of:
1. The impact of engineering activity on society and the environment.
2. The need to bring into engineering analysis and design considerations of:
    a) the impact of technology on society;
    b) the personal, social, cultural values and requirements of those affected by engineering activity.

2.8 Team and multidisciplinary working
The B.Eng./B.Sc.(Eng.) graduate is competent to
Work effectively as an individual, in teams and in multidisciplinary environments showing leadership and performing critical functions.

2.9 Lifelong Learning
The B.Eng./B.Sc.(Eng.) graduate understands
1. The requirements to maintain continued competence and to keep abreast of up-to-date tools and techniques;

and is competent to
Engage in lifelong learning through well developed learning skills.

2.10 Professional ethics and practice
The B.Eng./B.Sc.(Eng.) graduate is critically aware of
1. The need to act professionally and ethically and to take responsibility within own limits of competence;

and is competent to
2. Exercise judgement commensurate with knowledge and experience."