SYLLABUS: 1 JANUARY 1994

REPUBLIC OF SOUTH AFRICA

CO-ORDINATOR: ENGINEERINGSTUDY

SYLLABUS FOR

ENGINEERING SCIENCE N3

NATIONAL CERTIFICATE

CODE NUMBER

9216

EXAMINATION INSTRUCTION NO. 4 OF 1994

DATE OF IMPLEMENTATION
AUGUST 1994

DATE OF FIRST EXAMINATION
NOVEMBER 1994

1. SUBJECT AIMS FOR ENGINEERING SCIENCE

1.1 GENERAL AIMS

During the presentation of the modules of Engineering Science N3, care should be taken that the students understand each basic scientific principle in such a way that they will be able to incorporate this knowledge in their applied subjects.

1.2 SPECIFIC AIMS

On completion of all the modules of Engineering Science N3, the student should

* be able to apply the scientific principles mastered by him to his specific trade theory;
* be able to use the correct science terminology;
* be able to apply SI units and derived units correctly;
* be able to use acknowledged symbols, formulae and abbreviations correctly and to recognise appropriate formulae;
* be able to give and apply definitions correctly;
* possess the foreknowledge to proceed with Engineering Science N4;
* have mastered the basic scientific principles in such a way that he will be able to apply them in the working situation as well as in everyday life; and
* be able to function effectively in his working environment and to make sense of the extended technology in which he is involved.

2. DURATION OF INSTRUCTIONAL OFFERING

The duration of the instructional offering is one trimester (10 weeks/75 hours) full-time or one trimester (10 weeks/60 hours) part-time, which includes time for revision and tests.

3. EVALUATION

Candidates must be evaluated continually by conducting class tests on completion of each module.

4. EXAMINING

4.1 Reproduction, application, analysis and evaluation are important aspects in determining the degree of difficulty of this subject. The division of these aspects should be as follows:

REPRODUCING	APPLICATION	ANALYSING	EVALUATION
40	25	20	15

4.2 One three hour question paper totalling 100 marks will be set at the end of each trimester.

4.3 Only content specified as **LEARNING OUTCOMES** will be examined.

5. GENERAL INFORMATION

5.1 In order to bring the student into contact with the practical work situation, all calculations dealt with during the instructional offering should be based on problems encountered in practice.

5.2 The correct use of technical language and terminology should be stressed, especially in formulating definitions and concepts.

5.3 Answers to calculations must at all times be given correctly to three decimal numbers.

5.4 Before a calculation is attempted, the standard formula should first be written down. Depending on the question, the formula can then be manipulated or the given values substituted.
$g = 9,8\ m/s^2$ should be taken as the value for gravitational acceleration in all applicable calculations.

5.5 Neat, labelled line sketches must be drawn of specified apparatus.

5.6 Test/examination questions should be answered comprehensively. Answers consisting of a single word should be discouraged, except when such an answer is specified in the question.

5.7 Didactic guidelines must be regarded as hints which can contribute to the success of the presentation.

5.8 The weight value (WV) indicates the time which should be spent to conclude a module as well as the approximate weight the module should carry in the examination.

5.9 Exposition of subject matter

The subject is preceded by the word **MODULE**, followed by a

number indicating the chronological position of the subject. Decimal numbers indicate the CONTENT to be dealt with, and extended decimal numbers identify the expected LEARNING OUTCOMES.

6. SUBJECT MATTER

MODULE		WEIGHT VALUE
6.1	Motion, power and energy	(16)
6.2	Moments	(12)
6.3	Forces	(15)
6.4	Friction	(11)
6.5	Heat	(15)
6.6	Hydraulics	(12)
6.7	Electricity	(13)
6.8	Chemistry	(6)
		(100)

7. DETAILED SYLLABUS

MODULE 1: MOTION, POWER AND ENERGY

1.1 VELOCITY AND ACCELERATION

On completion of the topic, the student should be able to:

1.1.1 Describe velocity and acceleration and explain why both are regarded as vector quantities

1.1.2 Derive the formula $s = ut + \frac{1}{2}at^2$ from the formulae $s = \frac{1}{2}(u + v)t$ and $v = u + at$

1.1.3 Give and manipulate the following equations of motion:

$v = u + at$

$v^2 - u^2 = 2as$

$s = ut + \frac{1}{2}at^2$

1.1.4 Apply the above equations of motion in calculations.

DIDACTIC GUIDELINE

The content of 1.1.1 and 1.1.2 should be presented by means of the graphs of motion. These graphs will, however, not be examined.

1.2 FORCE, MASS AND ACCELERATION

On completion of the topic, the student should be able to:

1.2.1 Express the relation between force, mass and acceleration (Newton's second law) both in words and as a formula

1.2.2 Derive from the formula $F = ma$ the unit of force namely $kg.m/s^2$, and consequently describe the unit of force, the newton

1.2.3 Apply the formula $F = mg$ on gravity

1.2.4 Distinguish between balanced and unbalanced forces and explain the effect of such forces on a body - motion on horizontal planes only.

1.3 WORK DONE, ENERGY AND POWER

On completion of the topic, the student should be able to:

1.3.1 Describe work done, potential energy, kinetic energy and power

1.3.2 Give the law of conservation of energy

1.3.3 Apply the law of conservation of energy on linear motion on horizontal and inclined planes - friction (tractive resistance) is included

1.3.4 Calculate the work done and power transmitted as a result of a turning moment - restricted to constant motion only.

1.4 MOMENTUM

On completion of the topic, the student should be able to:

1.4.1 Give the law of conservation of momentum

1.4.2 Do calculations on momentum, limited to linear motion in the same plane, where collisions are concerned with e=1.

1.5 BELT DRIVES AND ANGLE OF CONTACT

On completion of the topic, the student should be able to:

1.5.1 Describe circumferential velocity, belt speed, effective pulling force and power

1.5.2 Do calculations on belt drives where the thickness of the belt is also considered

1.5.3 Name the effect of the angle of contact on a belt drive

1.5.4 Make a line sketch of a belt drive, showing the slack and tight side forces, direction of rotation and angle of contact.

DIDACTIC GUIDELINE

The student should be made aware of the fact that the concepts applicable to belt drives, as explained by means of flat belts, are also applicable to V and multi-groove belts.

MODULE 2: MOMENTS

2.1 CONDITIONS FOR EQUILIBRIUM (*For rotational equilibrium*)

On completion of the topic, the student should be able to:

2.1.1 Describe the moment of a force and the law of moments
2.1.2 Name the two conditions for equilibruim for a number of co-planar forces acting on the same point
2.1.3 Apply the conditions for equilibruim on moments in calculations.

2.2 LEVERS AND LAMINA

On completion of the topic, the student should be able to:

2.2.1 Apply moments on levers and lamina with fulcrums which are in equilibruim
2.2.2 Describe the moment of an oblique force
2.2.3 Do calculations on moments with oblique forces acting on the lever - the number of oblique forces are restricted to not more than one.

2.3 BEAMS

On completion of the topic, the student should be able to:

2.3.1 Calculate reactions at the supports of beams subjected to point loads, distributed loads and combinations of these - oblique forces are excluded; beams may be supported at any place
2.3.2 Make a sketch according to scale of a beam showing all loads and supports from a word problem
2.3.3 Draw, according to scale, shearing force diagrams and determine the maximum and minimum shearing forces.

MODULE 3: FORCES

3.1 CONDITIONS OF EQUILIBRIUM, THE TRIANGLE AND POLYGON OF FORCES

On completion of the topic, the student should be able to:

3.1.1 List the conditions of equilibrium of a system of forces

3.1.2 Describe what equilibrium, equilibrant, resultant and triangle of forces mean.

3.2 ANALYTICAL RESOLUTION OF PROBLEMS ON THE TRIANGLE AND POLYGON OF FORCES, RESULTANT FORCE, EQUILIBRANT AND UNKNOWN CO-PLANAR FORCES

On completion of the topic, the student should be able to:

3.2.1 Resolve forces analytically into horizontal and vertical components

3.2.2 Calculate analytically the sum of the horizontal and vertical components of a system of forces acting on the same point by using the following equations:
$S_{hc} = f_1\cos\theta_1 + f_2\cos\theta_2 + f_3\cos\theta_3 + \ldots\ldots$
$S_{vc} = f_1\sin\theta_1 + f_2\sin\theta_2 + f_3\sin\theta_3 + \ldots\ldots,$
where θ refers to the angle between the force and the horizontal plane

3.2.3 Calculate the magnitude of the resultant force (equilibrant) from
$R = \sqrt{(S_{hc}^2 + S_{vc}^2)}$

3.2.4 Calculate the direction of the resultant force from
$\text{Tan}\ \theta = S_{vc}/S_{hc}$

3.2.5 Determine the direction of the equilibrant from the principle that the directions of the resultant force and the equilibrant differ by 180°

3.2.6 Determine the magnitude and direction of unknown forces by applying the principles in 3.2.1 to 3.2.4.

3.3 SIMPLE FRAMEWORKS (ROOF TRUSSES)

On completion of the topic, the student should be able to:

3.3.1 Represent by means of a diagram a roof truss supported at two points, and carrying not more than three vertical loads

3.3.2 Determine graphically or analytically the nature and magnitude of the forces in the different frame parts - restricted to triangular roof trusses consisting of not more than nine frame parts.

DIDACTIC GUIDELINE

The directions of all forces should be described with reference to the horizontal axis, e.g. north or south from east or north or south from west

Problems may be solved either graphically or analytically - the method should not be specified.

MODULE 4: FRICTION

4.1 STATIC AND KINETIC FRICTION

On completion of the topic, the student should be able to:

4.1.1 Describe and calculate the static and kinetic coefficients of friction

4.1.2 Describe the method to determine experimentally the static and kinetic coefficients of friction on horizontal and inclined planes

4.1.3 List the advantages and disadvantages of friction as well as applications of friction in practice

4.1.4 Describe the effect of lubricants on friction.

DIDACTIC GUIDELINE

The static and kinetic coefficients of friction should be determined experimentally during the presentation of this section.

4.2 COEFFICIENT OF FRICTION, ANGLE OF FRICTION AND ANGLE OF REST

On completion of the topic, the student should be able to:

4.2.1 Describe friction force, coefficient of friction, angle of friction, angle of rest and normal reaction force

4.2.2 Calculate the angle of friction and coefficient of friction from
$\text{Tan } \theta = \mu = F_{\mu}/N$, N = normal reaction force

4.2.3 Calculate the angle of repose and give applications of the angle of repose in practice.

4.3 HORIZONTAL AND INCLINED PLANES

On completion of the topic, the student should be able to:

4.3.1 Calculate the forces acting on bodies on horizontal and inclined planes - forces acting parallel to the plane and forces making an angle with the plane are considered. In

this instance, the bodies may also be subjected to friction.

MODULE 5: HEAT

5.1 SPECIFIC HEAT CAPACITY

On completion of the topic, the student should be able to:

5.1.1 Define specific heat capacity and indicate the unit in which it is expressed

5.1.2 Briefly explain why the specific heat capacity of substances differ and what the meaning of the specific heat capacity of a substance is

5.1.3 Briefly explain the significance of the high specific heat capacity of water.

5.2 TRANSFER OF HEAT

On completion of the topic, the student should be able to:

5.2.1 Give the law of conservation of energy, as applied to heat

5.2.2 Indicate the way in which heat is transferred from one body to another by means of the law of conservation of energy

5.2.3 Apply the law of conservation of energy in calculations concerning mixtures consisting of not more than three substances.

5.3 HEAT VALUE OF A FUEL AND EFFICIENCY

On completion of the topic, the student should be able to:

5.3.1 Describe the heat value of a fuel

5.3.2 Do calculations on the heat value of fuels including the law of conservation of energy

5.3.3 Calculate the efficiency of machines and plants.

DIDACTIC GUIDELINE

The student must be aware of the fact that the heat value of a fuel is introduced only when the fuel is completely burnt out. During this process, heat is released, e.g. in power stations and

car engines.

5.4 EXPANSION

On completion of the topic, the student should be able to:

5.4.1 Describe area expansion and name the units in which it is expressed

5.4.2 Briefly discuss the consequences of heat expansion in practice (e.g. distortion at welded joints)

5.4.3 Apply and manipulate the formulae for the calculation of the linear and area expansion.

5.5 STEAM

On completion of the topic, the student should be able to:

5.5.1 Briefly describe the production of steam by means of a steam-boiler

5.5.2 Name the advantages, disadvantages and applications of steam

5.5.3 Describe the effect of a change in pressure on the saturation temperature

5.5.4 Use the steam tables to calculate the enthalpy of wet and dry steam

5.5.5 Calculate the dryness factor of wet steam.

MODULE 6: HYDRAULICS

6.1 HYDRAULIC PRESSES

On completion of the topic, the student should be able to:

6.1.1 Briefly describe the principle of hydraulic presses and draw a diagram of a hydraulic press
6.1.2 Do calculations on hydraulic presses
6.1.3 Discuss the application of this principle on hydraulic cranes (*implementing more than one cylinder*).

6.2 WORK DONE AGAINST A PRESSURE

On completion of the topic, the student should be able to:

6.2.1 Calculate the work done by single stroke pumps to deliver water against a pressure.

6.3 WORK DONE AGAINST A HEAD

On completion of the topic, the student should be able to:

6.3.1 Calculate the work done by a single stroke pump to deliver water against a head
6.3.2 Describe what is meant by static head, delivery head and suction head and interpret these concepts in problems.

DIDACTIC GUIDELINE

The sources of the pressure applied in hydraulic presses should be mentioned during the presentation of this topic.
The pneumatic equivalent should also be mentioned during the discussion of the hydraulic principles.

MODULE 7: ELECTRICITY

7.1 CELLS

On completion of the topic, the student should be able to:

7.1.1 Describe the effect on the potential difference, current and resistance of an electric circuit when the cells are connected in
(a) series, and
(b) parallel

7.1.2 Calculate the emf, potential difference, current and resistance (internal and external) of given electric circuits.

DIDACTIC GUIDELINE

This section should be presented as far as possible by means of electric circuits built in the classroom.

7.2 ELECTROLYSIS

On completion of the topic, the student should be able to:

7.2.1 Describe the electrochemical equivalent

7.2.2 Formulate Faraday's laws

7.2.3 Apply the principles set out in 7.2.1 and 7.2.2 to calculations on electrolysis

7.2.4 Name applications of electrolysis in practice.

7.3 JOULE'S LAW

On completion of the topic, the student should be able to:

7.3.1 Formulate Joule's law and give the applicable units

7.3.2 Calculate the cost of electric energy consumption (restricted to one item only).

7.4 POWER

On completion of the topic, the student should be able to:

7.4.1 Calculate the power and energy in direct current circuits.

7.5 ALTERNATING CURRENT AND DIRECT CURRENT

On completion of the topic, the student should be able to:

7.5.1 Name the differences between direct and alternating current and the distinguishing characteristics of each
7.5.2 Briefly reproduce and illustrate with sketches the magnetic effects of electric current.

7.6 THE SINGLE-PHASE TRANSFORMER

On completion of the topic, the student should be able to:

7.6.1 Make a neat, labelled sketch of a simple transformer
7.6.2 Describe the concept of load factor and explain the meaning of a high and a low load factor
7.6.3 Calculate the turns ratio, voltage ratio and current ratio of single-phase transformers with a given load factor.

DIDACTIC GUIDELINE

The student should be made aware of the fact that alternating current may also be three-phase.

MODULE 8: CHEMISTRY

8.1 ELEMENTS: THE CONSTITUENTS OF MATTER

On completion of the topic, the student should be able to:

8.1.1 Briefly describe element and matter

8.1.2 Name the component elements of the following alloys: brass, solder, silver steel, tungsten, phosphor bronze, bright steel and tool steel as well as not more than two properties of each alloy

8.1.3 Name the component elements of the following well known compounds: water, table salt, sulphuric acid, hydrochloric acid and limestone (marble).

8.2 THE PERIODIC TABLE OF THE ELEMENTS

On completion of the topic, the student should be able to:

8.2.1 Briefly explain the arrangement of the elements in the Periodic Table into periods and groups.

8.3 METALS AND NON-METALS

On completion of the topic, the student should be able to:

8.3.1 Briefly explain that the elements in the Periodic Table are divided into two main groups, namely the metals on the left-hand side and the non-metals on the right-hand side of the table

8.3.2 Identify a number of well-known metals, namely iron, copper, aluminium, zinc, tin, lead, gold and silver, as well as the following well-known non-metals: oxygen, hydrogen, carbon, nitrogen, chlorine and sulphur.

8.4 STRUCTURE OF THE ATOM

On completion of the topic, the student should be able to:

8.4.1 Briefly describe the structure of the atom in respect of:
(a) The position and composition of the nucleus

(b) The position and motion of the electrons
(c) The charge on the nucleus and the electrons

8.4.2 Briefly indicate that the bond between the nucleus and the outer electrons of the metal atoms is relatively weak, and that this phenomenon explains the electrical conductivity of the metals.

8.5 ELECTRON TRANSFER

On completion of the topic, the student should be able to:

8.5.1 Briefly explain that metals give off electrons relatively easy and that positive ions are formed as a result

8.5.2 Briefly explain that non-metals normally take up electrons and that negative ions are formed

8.5.3 Briefly explain why an aqueous solution containing ions can conduct an electric current which is the principle on which electrolysis and electroplating are based.

8.6 CORROSION

On completion of the topic, the student should be able to:

8.6.1 Describe oxidation, reduction and corrosion

8.6.2 Name the precautionary measures which can be implemented to combat corrosion.