SYLLABUS: 1 JANUARY 1994

REPUBLIC OF SOUTH AFRICA

CO-ORDINATOR: ENGINEERINGSTUDY

SYLLABUS FOR

ENGINEERING SCIENCE N2

NATIONAL CERTIFICATE

CODE NUMBER

9215

EXAMINATION INSTRUCTION NO. 4 OF 1994

DATE OF IMPLEMENTATION
APRIL 1994

DATE OF FIRST EXAMINATION
AUGUST 1994

1. SUBJECT AIMS FOR ENGINEERING SCIENCE

1.1 GENERAL AIMS

During the presentation of the modules of Engineering Science N2, 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 N2, 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 N3;
* 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
55	20	15	10

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	Dynamics	(15)
6.2	Statics	(10)
6.3	Energy and momentum	(7)
6.4	Work, power and efficiency	(10)
6.5	Mechanical drives and lifting machines	(17)
6.6	Friction	(9)
6.7	Heat	(11)
6.8	Particle structure of matter	(8)
6.9	Electricity	(13)
		(100)

7. DETAILED SYLLABUS

MODULE 1: DYNAMICS

1.1 DISTANCE, DISPLACEMENT, SPEED, VELOCITY, ACCELERATION AND TIME

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

1.1.1 Distinguish between distance and displacement, and between speed and velocity, and briefly describe each of these concepts

1.1.2 Indicate the relationship between distance, speed and time as a simple formula, and to manipulate and apply this formula ($\text{Speed} = \frac{\text{distance}}{\text{time}}$)

1.1.3 Indicate the relationship between displacement, velocity and time as a simple formula, and to manipulate and apply this formula ($\text{Velocity} = \frac{\text{displacement}}{\text{time}}$)

1.1.4 Define acceleration, and write it in the form of a simple formula ($a = \Delta v/\Delta t$), which must be manipulated and applied

1.1.5. Classify the quantities distance, speed, displacement, velocity, acceleration and time as scalars or vectors, according to their properties

1.1.6 Plot displacement/time graphs of linear
- (a) motion at constant velocity
- (b) motion with uniform acceleration, including free-fall as a result of gravity

1.1.7 Plot velocity/time graphs of linear
- (a) motion at constant velocity
- (b) motion with uniform acceleration starting from rest
- (c) motion with uniform acceleration and an initial velocity greater than zero
- (d) free-falling and vertically projected objects (air resistance not to be taken into account)

1.1.8 Give the meaning of the following:
- (a) Slope of a displacement/time graph
- (b) Slope of a velocity/time graph
- (c) Area beneath a velocity/time graph

1.1.9 Calculate from the graphs the quantities mentioned in

1.1.8

1.1.10 Derive from the graphs the following motion equations and manipulate and apply these TWO formulae:

(a) $v = u + at$

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

DIDACTIC GUIDELINE

Applications of the formula $s = ut + \frac{1}{2}at^2$ in 1.1.9 (b) must not include problems where the students must solve for t - solving of the quadratic equation is excluded.

MODULE 2: STATICS

2.1 PARALLELOGRAM OF FORCES, RESULTANT AND EQUILIBRANT

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

2.1.1 Define the parallelogram of forces, resultant and equilibrant
2.1.2 Determine graphically the magnitude and direction of the resultant and/or equilibrant or an unknown force by means of the parallelogram of forces
2.1.3 Resolve a force graphically and analytically into mutually perpendicular components
2.1.4 Describe the experiment and sketch the apparatus used for determining the components of a force.

2.2 MOMENT OF A FORCE

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

2.2.1 Describe the moment of a force
2.2.2 Reproduce the law of moments
2.2.3 Determine the reactions at the supports of a light horizontal beam supported at two positions and carrying perpendicular point loads only (not more than 4), and testing of the answers
2.2.4 Define a couple, give examples of couples and do calculations on couples.

DIDACTIC GUIDELINE

This section should be presented by means of practical demonstrations as far as possible.
Help or planning diagrams can aid the student in the solving of problems on the parallelogram of forces and beams.
The principles of translation and rotation equilibrium are applied in sections 2.1 and 2.2 respectively.

MODULE 3: ENERGY AND MOMENTUM

3.1 ENERGY

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

3.1.1 Define potential and kinetic energy
3.1.2 Formulate the law of conservation of energy
3.1.3 Derive, manipulate and apply the formula for the calculation of gravitational potential energy
3.1.4 Derive, manipulate and apply the formula for the calculation of kinetic energy
3.1.5 Apply the law of conservation of energy on a free falling object (restricted to the calculation of the potential and kinetic energy at different stages of the downward motion of the body).

3.2 MOMENTUM

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

3.2.1 Define momentum and supply a reason why momentum is regarded as a vector quantity
3.2.2 Calculate any unknown from the formula $p = mv$
3.2.3 Describe the concept angular momentum and explain the effect thereof on a rotating disc.

MODULE 4: WORK, POWER AND EFFICIENCY

4.1 WORK AND POWER

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

4.1.1 Define work and power

4.1.2 Plot force/distance graphs according to scale of the work done to lift a load by means of a cable/rope/chain of which the weight/mass must also be taken into consideration

4.1.3 Determine from the graph the average effective force as well as the work done, and then calculate the power required

4.1.4 Calculate the work done and the power required against resistance on a horizontal plane - restricted to motion at constant velocity and applied forces parallel to the plane only

4.1.5 Calculate work done and power exerted against gravitational forces - restricted to vertical motion only

4.1.6 Calculate work done and power exerted against an inclined plane, without taking friction into account

4.1.7 Calculate the work done by a torque.

DIDACTIC GUIDELINE

The naming of the axes of the graph and the values shown against the axes, must be stressed.

4.2 EFFICIENCY

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

4.2.1 Calculate the efficiency in the above-mentioned cases by using the formula
η = (Output/Input) x 100%, and manipulate the formula.

MODULE 5: MECHANICAL DRIVES AND LIFTING MACHINES

5.1 GEAR DRIVES (*Limited to gears in a single plane)*

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

5.1.1 Name the applications as well as the advantages and disadvantages of gear drives (gears and gearboxes as examples of couples)

5.1.2 Sketch single and compound gear trains and indicate the direction of rotation of the components

5.1.3 Calculate the rotational frequency and/or the number of teeth of the components of the gear train and the velocity ratio of the gear system.

5.2 BELT DRIVES

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

5.2.1 Name the applications as well as the advantages and disadvantages of belt drives

5.2.2 Apply and manipulate the applicable formulae to calculate the belt speed, effective pulling force, pulling force ratio and the slack and tight side forces of a belt drive

5.2.3 Calculate the power transmitted by a belt drive (the dimensions of the belt are not taken into account)

5.2.4 Name the methods applied in practice to reduce belt slip

5.2.5 Make a neat sketch of a belt drive showing the direction of rotation and the slack and tight sides of the belt.

5.3 CHAIN DRIVES AND TOOTHED BELT DRIVES

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

5.3.1 Name the applications as well as the advantages and disadvantages of chain drives and toothed belt drives

5.3.2 Compare gear, belt, toothed belt and chain drives with each other in respect of the above-mentioned.

5.4 LIFTING MACHINES

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

5.4.1 Describe a machine, efficiency, mechanical advantage and displacement ratio ($= \frac{\text{effort distance}}{\text{load distance}}$)

5.4.2 Make neat labelled line sketches of each of the following lifting machines:
(a) Differential wheel and axle
(b) Differential pulley block (Weston pulley block)

5.4.3 Apply and manipulate the applicable formulae to calculate the mechanical advantage, displacement ratio and efficiency of each of the above-mentioned lifting machines.

DIDACTIC GUIDELINE

Section 5.2 should be presented from first principles with special reference to the derivation of the formulae $v = \pi Dn$, $v = \pi DN/60$ and $P = (T_1 - T_2)v$.
The machines mentioned in 5.4 should be demonstrated during presentation of this section.
The applicable formulae should always be derived from first principles.
The students should take note of the fact that gears and gearboxes are good examples of couples.

5.5 HYDRAULICS

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

5.5.1 Describe atmospheric pressure and apply this concept in calculations

5.5.2 Name the factors determining the pressure exerted by a vertical liquid column

5.5.3 Briefly describe the effect of the depth and density of a liquid on the pressure exerted

5.5.4 Do calculations on pressure concerning the above aspects.

5.5.5 Give Pascal's law, and briefly explain the meaning of the law by means of an example, e.g. the pressure exerted on the embankment of a dam by the water

5.5.6 Describe gauge and absolute pressure

5.5.7 Calculate the gauge and absolute pressure from given data.

MODULE 6: FRICTION

6.1 FRICTION

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

6.1.1 Define static friction, kinetic friction and coefficient of friction and give the laws of friction

6.1.2 Name the advantages and disadvantages of friction as well as applications of friction in practice

6.1.3 Represent all the forces acting on a body subject to friction on both horizontal and inclined planes by means of a diagram

6.1.4 Define the angle of repose

6.1.5 Indicate and apply the relation between the coefficient of friction and the angle of friction and represent the angle of friction diagrammatically

6.1.6 Apply and manipulate the applicable formulae in order to calculate the coefficient of friction, angle of friction, weight components and the effective upward and downward pulling forces.

DIDACTIC GUIDELINE

During the presentation, the friction on horizontal and inclined planes should be demonstrated practically.
Calculations are restricted to constant linear motion and applied forces parallel to the plane only.
Applicable formulae should be derived from first principles.

MODULE 7: HEAT

7.1 HEAT AND TEMPERATURE

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

7.1.1 Define heat and temperature
7.1.2 Distinguish between heat and temperature.

7.2 HEAT CAPACITY AND SPECIFIC HEAT CAPACITY

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

7.2.1 Describe heat capacity and specific heat capacity and indicate the meaning of these concepts
7.2.2 Calculate heat gained/lost from the formula $Q = mc\Delta t$, and manipulate this formula.

7.3 LAW OF CONSERVATION OF HEAT

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

7.3.1 Formulate the law of conservation of heat
7.3.2 Apply the law of conservation of heat in calculations on mixtures consisting of a maximum of two substances.

7.4 HEAT VALUE

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

7.4.1 Define a fuel, name the three types of fuel and supply examples of each type
7.4.2 Define the heat value of a fuel
7.4.3 Do calculations on the heat value of fuels.

7.5 LINEAR EXPANSION

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

7.5.1 Name the advantages and disadvantages of linear expansion in practice

7.5.2 Define the coefficient of linear expansion

7.5.3 Calculate all the variables in the formula $\alpha = \Delta\ell/(\ell_o \Delta t)$.

7.6 STEAM

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

7.6.1 Describe the specific fluid enthalpy, specific enthalpy of evaporation and the dryness factor of wet steam

7.6.2 Indicate graphically the change ice → water → dry steam and explain what happens during each of the changes taking place

7.6.3 Briefly describe the effect on the boiling point of water when the pressure changes.

DIDACTIC GUIDELINE

This section should be presented by means of practical demonstrations as far as possible.
Die student should be made aware that hydraulic, carburettor and cooling systems work on the same principles as those introduced with steam.

MODULE 8: PARTICLE STRUCTURE OF MATTER

8.1 ATOMS AND STRUCTURE OF THE ATOM

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

8.1.1 Indicate that matter is constructed from atoms, i.e. that atoms are the basic constituents of matter

8.1.2 Briefly describe the construction of the atom in respect of the
(a) composition of the atom
(b) charge of the nucleus and electrons

8.1.3 Briefly discuss the transfer of electrons and the forming of positive and negative ions.

8.2 ELECTROLYTES

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

8.2.1 Supply a reason why a solution containing ions conducts electricity

8.2.2 Briefly explain why distilled water will not conduct electricity

8.2.3 Briefly explain what is meant by an electrolyte

8.2.4 Give examples from practice where electrolytes are used [electroplating, corrosion, batteries (electrolytic action)].

MODULE 9: ELECTRICITY

9.1 RESISTORS CONNECTED IN SERIES AND PARALLEL

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

9.1.1 Briefly explain the effect of resistors connected in series or parallel on the flow of current
9.1.2 Calculate the total resistance of not more than three resistors connected in series
9.1.3 Calculate the total resistance of not more than three resistors connected in parallel
9.1.4 Calculate the total resistance of not more than three series-parallel connected resistors.

DIDACTIC GUIDELINE

The water equivalent may be used to discuss the effect of series and parallel connected resistors.

9.2 RESISTIVITY (SPECIFIC RESISTANCE)

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

9.2.1 Briefly explain the meaning of the resistivity of a conductor
9.2.2 Name the factors that will determine the resistivity of a substance
9.2.3 Do calculations on resistivity by applying and manipulating the formula $R = (\rho.\ell)/a$ - the diameter of the conductor should also be taken into account.

9.3 ELECTROMAGNETIC INDUCTION, MUTUAL INDUCTION AND SELF-INDUCTION

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

9.3.1 Describe and illustrate by means of sketches the meaning of electromagnetic induction, mutual induction and self-induction
9.3.2 Name the advantages and disadvantages of the above-men-

tioned phenomena

9.3.3 Give examples of practical applications of mutual induction.