UNIVERSITY OF CAPE TOWN
FACULTY OF EDUCATION

AN ANALYSIS OF THE THEORY- AND EMPLOYMENT-DEMANDS ON MATHEMATICS FOR ELECTRICAL ENGINEERING PROGRAMMES AT TECHNIKONS

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**by
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ABSTRACT

A preliminary study indicated a degree of dissatisfaction with the present mathematics curriculum at technikons amongst academic staff members of technikons as well as members of the electrical-engineering industry. The hypothesis of this study is that the present mathematics curricula for electrical-engineering at technikons are not fully compatible with the demands emanating from the theoretical and the industrial-training (in-service or workplace) components of the training of electrical-engineering technicians.

The intent of this study is, firstly, to propose a framework of thought supporting engineering-mathematics curriculum-change in the context of electrical-engineering programmes as offered at technikons. The actual formulation of the syllabus content is supported by a curriculum-change model which takes cognisance of both the theoretical-demands and the workplace- demands in accordance with the aims of co-operative education espoused by technikons in South Africa. Secondly, a literature study of relevant past research leads to the development of a research methodology sympathetic to the present philosophy of technikon education for engineering-technicians in the country.

The research methodology involves, firstly, a questionnaire response from practising engineers and technicians. Secondly, it involves the gathering of suggestions from technikon academic staff and the analysis thereof by a work-group representative of all technikons, and led by the researcher. Thirdly, seventy-nine(79) reference-texts to the electrical-engineering programmes (study-levels 1 to 4), offered at the Peninsula Technikon, were analysed for its mathematical content.

The research findings supports the hypothesis. The thesis culminates in set of recommendations with regard to the applicability and composition of mathematics syllabi for electrical-engineering programmes at technikons.

CHAPTER 1

1.1 INTRODUCTION

In this chapter some basic concepts which are fundamental to this thesis are expanded upon in an attempt to reinforce a clearer understanding of the problem. The explication of the problem and the hypotheses of this research-study is further enhanced by expounding on some of the background to the problem in terms of the historical development of technikons as well as their aims and philosophy. Furthermore the purpose, structure, and monitoring criteria pertaining to the electrical-engineering programmes are clarified.

1.2 BASIC CONCEPTS

1.2.1 TECHNICIAN AND TECHNOLOGIST

As a result of the recommendations of the Goode Commission (1974) a clear distinction was formulated between a technician and a technologist (A.U.T. 1987 b,pp.5-10). A technician was defined as a person who applies technological knowledge and proven techniques within the framework of a specific industrial process. A technologist was described as a person who is required to perform advanced technological and intellectual tasks demanding more than just application of existing knowledge within the framework of a specific industrial process. On the basis of existing knowledge and research activity the technologist focuses on problem-solving and innovation. In contrast the professional practician finds that his/her responsibilities are not only tied to the inner processes of technology but are also concerned with the social implications for the industrial process. The professional practician therefore depends on relations with clients and outside institutions for his/her difference from the technician and technologist.The technologist focuses on technology while the professional practician focuses on the relation between technology and his/her fellow human. (A.U.T. 1987b.p.20).

1.2.2 INSTRUCTIONAL OFFERING AND INSTRUCTIONAL PROGRAMME

An instructional programme is defined as a structured composition of technological and vocational knowledge offered to students in the spirit of tertiary education at a technikon, ideally in co-operation with a specific industry, with the purpose of acquisition of a technikon qualification (AUT 1987b, p.23).

There is a distinct technological and vocational bias built into the definition above which distinguishes it from a course which is defined by the Oxford dictionary as a series of lectures.

An instructional-offering (also offering) forms a subset of technological and vocational knowledge within an instructional programme in the same way as a subject forms a subset of knowledge within a course.

1.2.3 CO-OPERATIVE EDUCATION

"Co-operative Education is a strategy of applied learning which is a structured programme developed and supervised by an educational institution in collaboration with an employing organisation in which relevant productive work is an integral part of a student's regular academic programme and is an essential component of the final assessment. Such programmes should normally commence and terminate with an academic period and the work experience should involve productive work and should comprise a reasonable proportion of the total programme" (Davie et.al 1988 p.70). The implication in this definition is an educational plan which integrates classroom experience and related in- service experience in industry, commerce and service type work. In many instances co-operative programmes exist between educational institutions and industry which must not be confused with co-operative education. For example, students may take up vacation jobs or become involved in community programmes. No matter how relevant these programmes may be, they do not meet the requirement for structure and supervision by the educational institution.

1.3 STATEMENT OF THE PROBLEM

For nearly a decade the Engineering-Mathematics syllabus at technikons in South Africa has changed little in the face of a fast changing technology. During preliminary interviews with technikon lecturers of the electrical-engineering discipline they have hinted at certain inadequacies of the engineering-mathematics syllabus which has to form a base for the theoretical understanding of the instructional-offerings taught by them. Furthermore studies, both abroad and local (see chapter 3), have indicated that the use of mathematics in the workplace of the technician is ever increasingly affected by the application of the computer. As technikon educational philosophy is based on the concept of co-operative education (C.T.P.1986 pp22-24) it is important that any instructional- offering satisfies the demands of both theoretical training and industry served by the instructional programme of which the instructional-offering is a part. Although the technikon infra-structure provides liaison facilities between technikons and industry, the discussion of mathematics as an instructional-offering is very seldom on the agenda. This situation is not peculiar to South Africa but is also noted overseas. The Department of Education and Science Report by H.M. Inspectors on a survey of mathematics in Further Education carried out in 1980 in the United Kingdom, indicates very little contact between Colleges for Further Education and industry relating to mathematics as a subject. Contact with industry is imperative to determining the demands on mathematics as a supporting science. The lack of contact is cause for concern as "unemployment can result just as easily from forms of education and training for which there is no demand as it can from lack of training or illiteracy" (H.S.R.C.1981,p.138). Over the years technikons developed a sophisticated infra-structure to effect curriculum-change (Komitee van Technikon Hoofde 1986). In terms of the position of mathematics at the technikon as a supporting science, the domain of its service to a specific discipline is defined by the mathematical content of all instructional-offerings embraced by the instructional-programmes within that discipline, as well as the workplace experience to be encountered by present and future generations of technicians.

1.4 HYPOTHESIS

the hypothesis of this thesis is that the engineering-mathematics curricula pertaining to electrical-engineering programmes at technikons, do not fulfil the present and foreseeable future needs of technicians.

1.5 PRELIMINARY STUDY

A preliminary study involved, firstly, interviews with senior staff members of three engineering related companies in Cape Town. All staff interviewed were engaged in the electrical-engineering discipline. Secondly one hundred log-books, designed to record and monitor the workplace experience of trainee electrical-engineering technicians, were scrutinised in order to get an idea of the mathematics used in the workplace. The log-books were chosen at random from those returned to the electrical-engineering department of Peninsula Technikon. Thirdly academic staff members of the electrical-department of the Peninsula Technikon were interviewed to elicit their views on engineering-mathematics syllabi.

The deductions which could be made from the interviews with industry staff were ambiguous. One company indicated a degree of dissatisfaction with the mathematical background and ability of trainee and qualified technicians when they are exposed to calculations involving advance mathematics, while the other two indicated that very little mathematics was required. The log-book scrutiny revealed that trainee-technicians' logbook reports did not contain any reference to mathematics calculations. It is clear that the technikon has, up to now, neglected the explicit monitoring of the use of mathematics as an element of co-operative education. This neglect of the monitoring of mathematics may be regarded as unworthy of emphasis due to the fact that the underlying mathematical structure is implicit in the work done by the technician in the workplace. However, one can argue that it is necessary and important for the technikon to keep abreast with calculating techniques and new trends in mathematics required in industry. Only then can the co-operative educational nature of mathematics be realised. The interviews with academic staff revealed only some discontent with the emphasis that some mathematics topics receive in engineering-mathematics as an instructional-offering.

1.6 BACKGROUND TO THE PROBLEM

The problem cannot be stated in isolation from its background. The development of the technikons, their philosophy and aims, with particular reference to co-operative education, are expounded on below.

1.6.1 THE TECHNIKON IN THE R.S.A.

According to the report " Sapse 118 of the University and Technikon Advisory Council "(1987b pp.5-9), state-assisted post-school technical education has its origins in the support given to railway institutes in the late 19th century and the South African School of Mines established in 1896 in Kimberley. Further involvement of the state is signalled by the Apprenticeship Act of 1922 which made it the duty of technical colleges to be responsible for the theoretical training of apprentices. By the promulgation of the Higher Education Act of 1923, some technical colleges were upgraded to Institutions of Higher Education and were placed under the control of a central education department. By 1955 there were ten technical colleges resorting as Colleges for Advanced Technical Education (C.A.T.E.s) under the state in accordance with the Higher Education Act of 1923 (Act 30 of 1923). In 1955 further state control was brought about by Act 70 of 1955 which transferred the maintenance and management of the C.A.T.E.s and state-subsidised vocational schools to the Minister of Education, Art and Science. Act 40 of 1967 makes provision for advancement of four "non-white" colleges to the status of C.A.T.E.s. At this stage all other C.A.T.E.s adopted Act 40 (of 1967) instead of Act 30 of 1923 which required more flexibility from the colleges by way of spreading their mandate to include both technical school and post-school education.

Act 40 of 1967 established the C.A.T.E.s as institutions catering for post-school technical education only. Although the C.A.T.E.s

now had a clear tertiary-education mandate, their status was still regarded as lower than that of the university. In fact, on "introducing the draft bill, the then Minister of Education said that the C.A.T.E.s would cater for technical education at a level between the secondary and
university levels. This suggestion of a hierarchical order, i.e. secondary/technical/university education, was often referred to at the time in discussions of the matter" (Van Wijk de Vries 1974,p. 173). In 1974 the recommendations of the Van Wijk de Vries Commission on the role of the C.A.T.E. vis-a-vis that of the university, followed by the recommendations of the Goode Committee Report on the status of the engineering-technician in the R.S.A., led to the promulgation of Act 43 of 1979 which advanced the C.A.T.E.s to TECHNIKONS to ensure their status as tertiary institutions parallel to universities.

1.6.2 THE AIMS OF THE TECHNIKON

The three main objectives of technikons are summarised by the Sapse 118 Report (1987) of the Advisory Council for Universities and Technikons (A.U.T.). The first aim focuses on the formative aspects of the technikon student. Technikons endeavour to improve the understanding by the student of life in general but more specifically in the field of study or vocation. Instructional-offerings are therefore designed to enhance the insights necessary for achieving this aim.

The second aim is to prepare students for a specific vocation as opposed to university preparation which may be of a nature so general that the student may not be sure at the outset as to what his/her vocation will be. This aim places specific demands on technikon programmes. The philosophy and practise of co-operative education form the basis of this aim. Co-operative Education philosophy as adopted by the technikons is the basis for co-operation between the technikon and industry in the task of educating the student. The technician or technologist must be able to perform his/her task fully in the workplace without further training after completing his/her programme obligations.

The third aim is directed at the promotion of technology through teaching, research and development as well as service to industry. Technikon programmes are structured to produce diplomates who are fully prepared to ful il their tasks immediately and effectively in the workplace. Technikon academics are required to do research and develop new products and processes. Research is seen as having educative as well as an industrial oriented objective. The expertise of the academics must be made available to industry and commerce with the aim of strengthening the ties between technikon, industry and commerce. Lecturers may act as consultants to industry and commerce which could enhance their teaching. It is stated that it is inconceivable that a technikon lecturer does not have regular meaningful contact with industry and commerce. (A.U.T.1987b ,pp.32-36)

1.6.3 <u>EARLY HISTORY OF CO-OPERATIVE EDUCATION PROGRAMMES</u>

In the U.S.A. co-operative education started at the University of Cincinnati in 1906. After a period of gradual growth major developments started in the 1950's. In 1956 Canada entered the field with the University of Waterloo offering co-operative engineering programmes. In Britain, while there are claims that sandwich-courses (British equivalent) began at the University of Glasgow in 1840, credit for their origin is generally given to Sunderland Technical College (now Sunderland Polytechnic). Major expansion in Britain in the 1950's influenced Australia with her first successful programme in 1963. In Australia the term "sandwich-courses" has gradually given way to the term "co-operative education". Programmes in Hong Kong and Singapore also appear to be influenced by Britain. (Davie et. al 1988 p.71).

1.6.4 <u>CO-OPERATIVE EDUCATION IN SOUTH AFRICA</u>

In the R.S.A. co-operative education is generally accepted in principle but its application in the technikon programmes is limited to the extent that disciplines such as commerce and management are excluded because of difficulties in implementation (A.U.T. 1987b.p.57). The Committee of Technikon Principals (C.T.P.) which is an advisory link between technikons and the government on technikon policy sets out the following ideals for co-operative education.

Co-operative education involves the technikon and industry as partners in the formulation of an educational programme qualifying students for employment in industry. The partners in this venture are equal but the final responsibility and accountability rests with the technikon. The alternating action in the fulfilment of the programme between the technikon and industry is structured in accordance with various demands on the theoretical and in- service requirements of the programme. An optimal programme ensures that the theoretical component, as offered at the technikon, and the in- service component in the workplace reinforce each other. The optimal alternating action should not be disturbed by ulterior motives such as convenience and lack of funds. The ratio, theory/in- service component, can vary notably for the same technology in accordance with the demands of the level of study of the programme. (C.T.P.1986,pp.22-24).

The in- service or experiential component is an extension of the formal components (theory and laboratory) of the education of a technikon student. As such the in- service component is monitored by the technikon and forms part on the final report on the diplomate. (A.U.T. 1987b).

1.7 THE STRUCTURE, PURPOSE AND MONITORING OF INSTRUCTIONAL-OFFERINGS OF THE ELECTRICAL-ENGINEERING INSTRUCTIONAL-PROGRAMMES AT THE PENINSULA TECHNIKON

We now have a look at the purpose and structure of electrical-engineering instructional programmes as well as the monitoring thereof in terms of the co-operative education philosophy which makes the technikon responsible for acceptable in- service training in the workplace.

(a) **Purpose of instructional-offerings:-**

Electrical-Engineering courses are conducted within the framework of co-perative education. Students thus alternate between periods of study at the Technikon and periods of in-service training in industry. There are two main streams of courses. The first being the National Diploma and National Higher Diploma in Electrical Engineering (Light Current) and the second stream the National and National Higher Diploma in Electrical Engineering (Heavy Current). "The electrical- technician (light current) is concerned with maintenance and development of electronic equipment such as television, control systems, transmission equipment, instrumentation and basic computers ... The electrical-technician (heavy current) is concerned with the generation and distribution of electricity and its uses for power as well as testing and commissioning of equipment." (Peninsula Technikon 1989 p.13).

(b) Duration of instructional programmes:-

The National-Diploma course involves three semesters full-time attendance at the technikon alternating with an equal period of approved in-service training. An additional semester of full-time attendance is required for the National Higher Diploma course, with an equal period of in-service training . The in-service training component entails practical training in industry monitored by the technikon through a written student report in the form of a log-book (see appendix 4).

(c) Programme structure

The heavy-current instructional programme is further subdivided to give the student an option two sub-programmes, viz. a programme leading to the Government Certificate of Competency and secondly Electronic Control of Heavy Machinery. The light-current programme is further subdivided to give the student an option of three sub-programmes, viz. Communication Electronics, Industrial Electronics and National Diploma in Technology (Peninsula Technikon 1989 pp.15-16).

(d) **Instructional-offerings:-**

The instructional-offerings contained in the electrical-engineering instructional-programme are listed in tables 1.1.(a) & (b).

INSTRUCTIONAL-OFFERING CODES AND RELATED PROGRAMMES

Legend:- X = compulsory
O = optional
XO = compulsory for certain sub-programmes

		PROGRAMME	
CODE	**INSTRUCTIONAL-OFFERING**	**HEAVY CURRENT**	**LIGHT CURRENT**
TDA.1	Digital Systems T.1	X	X
TEI.1	Electronics T.1	X	X
TEJ.1	Electrical Engineering T.1	X	X
TIC.1	Industrial Instruments T.1	O	X
TID.1	Industrial Technology T.1	O	X
TIE.1	Industrial Technology T.1	O	X
TIJ.1	Engineering Mechanics T.1	X	X
TIO.1	Engineering Mathematics T.1	X	X
TDA.2	Digital Systems T.2	X	X
TEF.2	Electrical Machines T.2	X	-
TEI.2	Electronics T.2	X	X
TEK.2	Electrical Engineering T.2	X	-
TEL.2	Electrical Engineering T.2	-	X
TIC.2	Industrial Instruments T.2	-	X
TID.2	Industrial Technology T.2	O	X
TIE.2	Industrial Technology T.2	O	-
TIF.2	Engineering Management T.2	O	O
TIO.2	Engineering Mathematics T.2	X	X
TSH.2	Strength of Materials T.2	X	-
TTB.2	Telecommunications T.2	-	X

Table 1.1 (a)

		PROGRAMME	
CODE	INSTRUCTIONAL-OFFERING	HEAVY CURRENT	LIGHT CURRENT
TDA.3	Digital Systems T.3	X	X
TEF.3	Electrical Machines T.3	X	-
TEG.3	Electrical Measurements T.3	O	-
TEH.3	Electrical Instruments	-	X
TEI.3	Electronics T.3	O	XO
TEK.3	Electrical Engineering T.3	X	-
TIA.3	Illumination T.3	XO	XO
TIB.3	Industrial Electronics	X	XO
TIC.3	Industrial Instruments	-	O
TIF.3	Engineering Management T.3	O	O
TIO.3	Engineering Mathematics T.3	X	X
TOG.3	Automatic Control T.3	XO	XO
TRB.3	Radio Engineering T.3	-	O
TSH.3	Strength of Materials T.3	X	-
TTC.3	Television	-	X
TDA.4	Digital Systems T.4	-	X
TEF.4	Electrical Machines T.4	X	-
TEG.4	Electrical Measurements T.4	O	-
TEH.4	Electronic Measurement T.4	-	X
TEK.4	Electrical Engineering T.4	X	-
TER.4	Electronic Design T.4	O	X
TIO.4	Engineering Mathematics T.4	O	O
TOG.4	Automatic Control T.40	X	O
TSH.4	Strength of Materials T.4	X	-
TTC.4	Television T.4	-	X

Table 1.1 (b)

For the sake of simplicity the offering-codes used by the Electrical Department at the Peninsula Technikon have been shortened by deleting the last two digits. For example, the code for Digital Systems T.1 has been shortened from TDA111 to TDA1. Each instructional-offering name is suffixed by Tn (n=1,2,3 or 4). The number n indicates the semester of study. Corresponding syllabi appear in Appendix 5.

(e) **The monitoring of the in-service/experience component of training.**

In accordance with technikon perception of co-perative education, the in-service training of the aspirant technician is monitored by the technikon. Co-perative education programmes are developed, inter alia, using the following criteria:

(a) The student must be engaged in productive work.

(b) The students' progress is constantly being monitored by the technikon.
(c) The students' performance on the job is supervised and evaluated by both the employer and the technikon.
(d) Each work station is developed and/or approved by the technikon as a suitable learning station(Pen.Tech.1989b).

In-service training is mandatory for technikon students and diplomas are only awarded upon successful completion of between 12 and 18 months industrial experience. The workplace performance of the student is monitored through structured site visits by academic staff as well as a written report by the student. This report takes the form of a log-book (see appendix 4).

In the following chapters a curriculum-design model is sought to facilitate proposed changes to the syllabus content for engineering-mathematics. in order to formulate a research methodology, relevant research which takes cognisance of the co-operative nature of engineering-mathematics, is consulted. The data generated by this research methodology is analysed, culminating in a set of recommendations in the final chapter.

CHAPTER 2

THE CURRICULUM

2.1 INTRODUCTION

The syllabus content of engineering-mathematics as an instructional-offering cannot be discussed without reference to curriculum design. The various steps of the curriculum- design process interact with each other and one of the steps is the determination of syllabus content.

In this chapter a brief overview of curriculum design is given. Some curriculum-design frameworks will be discussed followed by a look at various curriculum-design models.

2.2 CURRICULUM DESIGN

"The curriculum is all of the learning of students which is planned by and directed by the school to attain educational goals" (Tyler: 1957 p.79). According to Tanner & Tanner (1975 p.451), the curriculum is described as "... the planned and guided learning experiences and intended outcomes, formulated through systematic reconstruction of knowledge and experiences, for the learners' continuous and wilful growth in personal-social competence". From these definitions it is clear that the curriculum is goal directed. Instructional objectives are stated in terms of measurable learner behaviour. "(The Curriculum) encompasses aims of education, content, methods and assessment procedures." (Howson et. al 1981 p.2). The three commonly-used curriculum-design frameworks are termed:-

1. The management framework (Kleibard 1971)
2. The systematic framework (Banathy 1968)
3. The open-access framework (Wilson 1971)

2.2.1 THE MANAGEMENT FRAMEWORK

The management framework involves decision-making processes evolving from a broad base with the final decision made by a single manager. In autonomous institutions this manager will be the principal whereas in centralised government institutions the manager will be "the department" (Kleibard 1971).

2.2.2 THE SYSTEMATIC FRAMEWORK

The systematic framework is based on a feedforward/ feedback approach (Banathy 1968). The framework involves a situation analysis, formulation of aims and eventually culminating in an evaluation process.

2.2.3 THE OPEN-ACCESS FRAMEWORK

In the open-access framework decisions are based on consistency with values derived from humanist tradition (Wilson 1971). Goals are specified which will provide learning experiences that students will judge to be significant to them as individuals so as "to develop persons who are committed to the value and the work of each and every human being as the central value of existence" (MacDonald 1969 p.48). In this framework an open inquiry is maintained into all curriculum-related matters (Diab. 1987 p.12).

2.3 RELEVANT MODELS FOR CURRICULUM DEVELOPMENT

A question that has received intensive attention by Howson and Malone (1986 pp.187-196) is whether curriculum development in mathematics differs from that of other subjects. It is their contention that the emphasis that employers and the general public place upon attainment in mathematics supports a different curriculum development process. Within the general context of educational theory several models for curriculum development have been suggested by Wheeler's (1967) cyclic objectives-evaluation approach and Tyler's (1971) rational planning, emphasising behavioural and content objectives. Bruner (1960) suggests that the understanding of fundamentals makes an instructional-offering more comprehensible; that organising knowledge in terms of principles and ideas assist the memory function; that the mastery of general principles is the basis for effective transfer of knowledge and that the emphasis of fundamentals assists in narrowing the gap between elementary and advanced knowledge.

2.3.1 THE KRUGER MODEL

In South Africa a model for curriculum development been proposed by Kruger (1979) and modified by Laridon (1981) for secondary-school mathematics. This model and its modification falls within the systematic framework and is advocated as a design model for mathematics curricula. The Kruger model is six-step model with a spiral approach to the curriculum process. The steps are:-

(i) a situation analysis
(ii) determination of goals
(iii) selection and planning of learning experiences
(iv) selection and structuring of content
(v) proposed learning experiences
(vi) evaluation

2.3.2 DE-LANGE MODEL

The de Lange Report (H.S.R.C.1981a) and in particular, the Report of the Work Committee of the de Lange Commission of inquiry into the teaching of the Natural Sciences and Mathematics (H.S.R.C.1981b) made specific recommendations with regard to curriculum development for both mathematics and the natural sciences. A relevant curriculum procedure was recommended:-

(i) The overall aim, purpose and philosophy of the syllabus should be determined. This preliminary discussion will enable the aims of the syllabus and the criteria for the selection of content to be clearly identified.
(ii) A draft syllabus should be drawn up and comments sought from a wide spectrum of individual institutions.
(iii) Based on the syllabus, support materials such as text books, teachers' guides, laboratory manuals etc., should be prepared.

(iv) The syllabus and support materials should be tested and an appropriate orientation programme for teachers involved should be organized.

(v) Revision of the syllabus and curriculum materials in the light of step 4.

(vi) The revised syllabus and curriculum materials should be tested once more.

(vii) Final revision of the syllabus and curriculum materials.

2.3.3 <u>THE TECHNIKON MODEL.</u>

The Kruger model corresponds very closely to the curriculum development model espoused by technikons (K.T.H 1986 p.2). A schematic representation of the technikon curriculum-change model is depicted in figure 2.1.

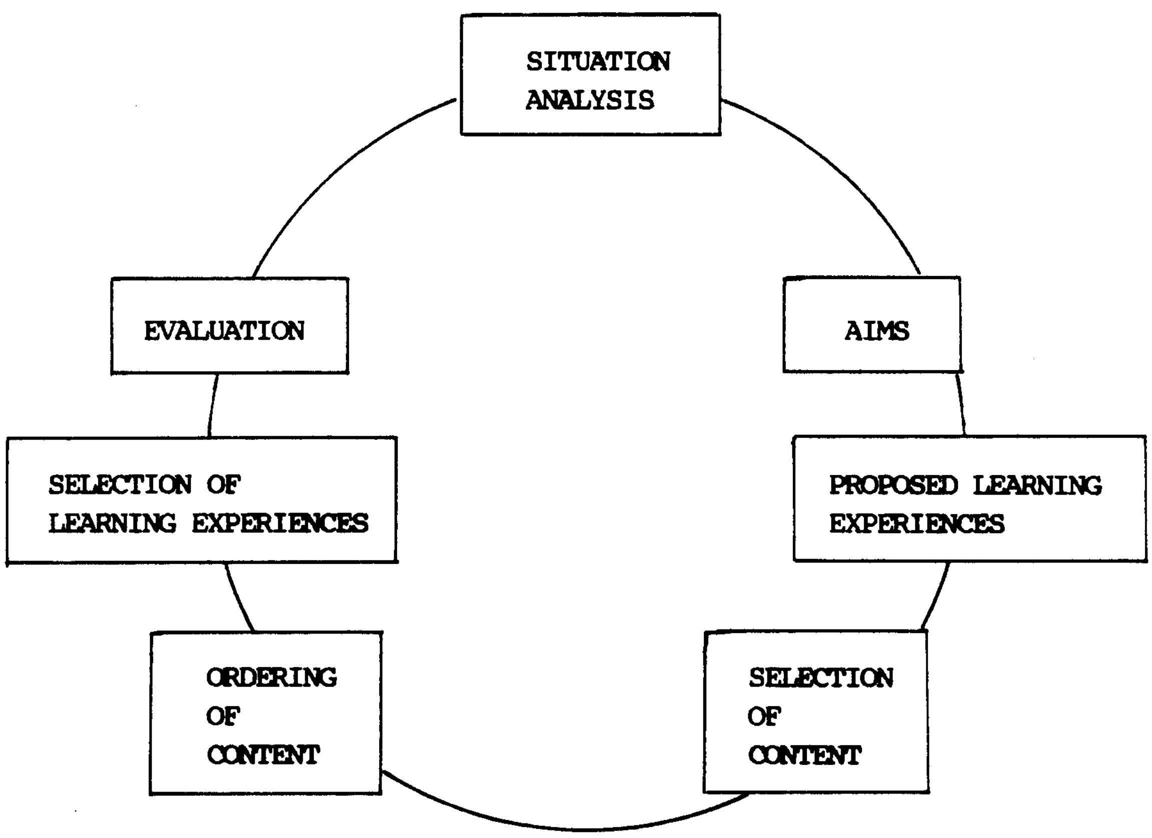


Figure 2.1

The foregoing models can easily be accommodated by the systematic feedforward/feedback framework in which decisions can be taken by many as long as the reciprocating system is maintained.

2.3.4 ADAPTATION OF KRUGER MODEL FOR TECHNIKON MATHEMATICS.

The Kruger and Laridon curriculum-development models for mathematics at secondary schools can be adapted for engineering-mathematics at technikons. In the proceedings of the Technikon Mathematics Conference at Scottburgh, Natal, Van Rooy (1987 p.103), suggests the following approach:-

(a) The situation analysis

(i) The syllabus for engineering-mathematics at the technikon should be take cognisance of the students' vocational needs, entry level (mathematics proficiency at entering the instructional-offering), and the way engineering-mathematics should be taught at the Technikon.

(ii) An investigation comparing the mathematical needs of industry, the departments of engineering at technikons with the current engineering curricula is required.

(iii) A sound perspective on the role of mathematics in technikon education is necessary. Mathematics should not be regarded as a pure service offering but rather as a supporting science. "What I find particularly depressing, where it exists, is the continuance of the philosophy, in quarters where they really do know better, that there is some kind of obligation upon mathematics-departments to (as it were) give the customer what he wants and if all he wants is (say) an idiot's guide to the use of Laplace-transform tables, then that is exactly what he is going to be given. In my view, no reputable mathematician can be a party to this kind of prostitution. Mathematics is not just a series of techniques ......" (Graham Flegg 1974 pp.65-74).

One can add to the situation analysis the environment to curriculum design created by technikon philosophy. The elements of co-operative education set out in Chapter 1 must be brought to bear on the analysis. In other words curriculum design must ensure that industry honour the curriculum by considering the training component as an extension of the theoretical component. This means that the in- service component must be incorporated in curriculum design.

(b) Aims, goals and objectives

Van Rooy (1987) continues as follows:-
"From this investigation of situational factors we must identify, formulate and operationalise the aims of teaching mathematics at technikons." The aims are identified as follows by Van Rooy :-

(i) Developing logical thinking.
(ii) Awareness of the inter-relationships between mathematics and other branches of knowledge.
(iii) Proficiency in utilizing calculating devices.
(iv) Understanding the applications of Mathematics in industry.
(v) Ability to compute accurately and to estimate and verify answers where necessary.
(vi) Ability to solve problems in Mathematics using basic concepts, principles and procedures.
(vii) Ability to apply mathematics in other relevant subject areas.
(viii) Understanding the ways in which computers can be used to solve mathematical problems.
(ix) Understanding the technical meaning of mathematical symbols, terms, concepts etc.
(x) Grasping the importance of logical deductive procedures in doing Mathematics.
(xi) Insight into relevance of Mathematics for specific occupations.
(xii) Ability to pass Mathematics examinations.
(xiii) Insight into own abilities in doing Mathematics.

The above aims can be collapsed into the following categories:-

1. Logical deductive processes and methods of thinking.
2. Relationships, applications and relevance with respect to other offerings, industry and vocational situations.
3. Computations using basic concepts, procedures and calculating devices.
4. Successful study and practice in Mathematics.

(c) Course content

Three selection criteria for course content relevant to the technikon's mathematics-syllabus content are:-

(i) Mathematical prerequisites, i.e. the internal or vertical relevance of mathematics topics in terms of a hierarchical learning strategy which places the learning of a set of predetermined topics as a prerequisite for the understanding of other topics.

(ii) External or horizontal relevance i.e the supporting value of mathematics for engineering offerings and relevant industry.

(iii) Realism, i.e. realistic as far as the capabilities of the students are concerned.

(d) Teaching, learning-activities, experiences and opportunities

This includes the means, material and methods needed for effective knowledge transfer so as to meet the aims and objectives.

(e) Evaluation

Progress towards the realisation of the set aims must be judged. This means evaluation of both process and product i.e. evaluating not only the results achieved by the students but also the results of the curriculum itself by evaluating each component thereof.

2.4 THE CURRICULUM MODEL ADOPTED BY THIS STUDY

For the purposes of this investigation it is suggested that the Kruger model, as adapted by Van Rooy for technikon mathematics, should serve as a premise. This adoption is based on the clarity with which Van Rooy has incorporated the unique nature of technikon education in his adaptation of the Kruger model. This research project attempts at performing a situation analysis focusing on the student's vocational needs. These vocational needs will be viewed in terms of the needs in the work situation as well as in theoretical training. Secondly, relationships, applications and relevance of mathematics with respect to other instructional-offerings, industry and vocational situations, will enjoy prominence. Finally, the scope of this project terminates at the third step, viz., the selection of course content based on the three selection criteria set out in (2.4.c).

2.5 SUMMARY

In the last two chapters the problem was stated, the background of the problem was sketched in terms of an historical perspective of the technikon, culminating in a focus on its aims and philosophy with special reference to co-perative education. Attention was drawn to the electrical-engineering instructional programmes in terms of purpose, composition and its co-perative-education monitoring system. Directed by the central theme of this study an overview of curriculum change was given, leading us to the adoption of the Kruger curriculum-change model as adapted by Van Rooy. With this background we now proceed in the following chapter to view research relevant to this study with the aim of developing a research methodology.

CHAPTER 3

RELEVANT RESEARCH

3.1 INTRODUCTION

In this chapter an overview is given of five studies on the desirability of the mathematics syllabus as an instructional-offering to engineers. The intent is to extract from t ese studies some indicators which may assist with the formulation of a research methodology for this study .

3.2 THE USE OF MATHEMATICS IN THE ELECTRICAL INDUSTRY - a U.K.study conducted in 1966.

The U.K. study was conducted by M.R.Scott, A.Brooks, A.W.Lee and H.B.Ramsay under the auspices of the Nuffield Foundation. The purpose of the study was to determine the use of mathematics in the electrical industry (Scott et.al.1965).

The methodology involved a set of three postal questionnaires to extract information from a much wider sample of electrical engineers than would be possible by the method of personal interview. The necessity for survey of this type was prompted by the notion that a busy engineer who is engaged mainly in administrative duties and consequently has lost the retention of a substantial part of the mathematics which has been learned during theoretical training, would be reluctant to grant an interview but might be more willing to spend a few minutes completing a questionnaire. The selection of the sample for the postal questionnaire was effected through the institutions of Electrical Engineers since names and addresses of graduate as well as non-graduate engineers were readily available. A random sample of one in seven was selected and 5000 questionnaires were sent out. A 63% response was obtained. The predominant use of pre-coded questionnaires was a weakness which excluded possible comments. The magnitude of the sample suggested pre-coding for expediency as an analyses of comments on 5000 questionnaires would have been too time-consuming. The main questionnaire was designed to categorise the use of various topics in Mathematics according to the nature of work , age and education of respondents. Furthermore pre-selected reasons for not using mathematics were elicited. Two types of questions were excluded from the main questionnaire as it was hypothesised that they were only applicable to a minority. These questions, pertaining to the use of advanced mathematics topics and computers, formed the basis for the second and third questionnaire which, although pre-coded, allowed for amplification of responses. The results of the main questionnaire are tabulated below:-

THE USE OF MATHEMATICS

	Percentages			
	Never	Some-times	Often	No of replies
a) Arithmetic etc.	-	12	88	2938
b) Elementary algebra etc.	5	35	60	2938
c) Elementary calculus etc.	29	41	30	2938
d) More advanced mathematics				
By nature of work				
I. Research and Development	28	47	25	661
II. Design	60	34	6	735
III. Production	80	16	4	149
IV. Installation and Operation	87	12	1	480
V. Sales and Tendering	92	7	1	220
VI. Executive Administration	75	22	3	426
VII. Teaching	10	30	60	169
VIII. General	75	21	4	39
IX. Computation	37	42	21	20
X. Patents and Consulting	64	26	10	39
TOTAL	59	29	12	2938
By age:				
39 years and under	53	33	14	1029
40 to 49 years	59	30	11	1082
50 to 59 years	71	19	10	524
60 years and over	69	21	10	151
By education:				
Graduate	48	34	18	1365
Non-graduate	73	21	6	1289

Table 3.1

Preselected reasons for not using mathematics are depicted below:

Question A 4 "If you do not use any mathematics other than simple calculations, which of the following reasons apply?

a) There is no scope for use of mathematics in my work.
b) I am unfamiliar with the appropriate mathematical methods.
c) Mathematicians for consultation are not available.
d) The mathematical treatment is known but the calculations involved are too tedious.
e) The appropriate mathematical techniques have not been developed.
f) Pressure to get results leaves insufficient time for any new approach.
g) I do not trust mathematical methods.
h) Experimental methods are more appropriate.

REASONS FOR NOT USING MATHEMATICS

	REASONS (PERCENTAGE)		
NATURE OF WORK	(a)&(h)	(b)-(g)	No of replies
I. Research and development	47	53	131
II. Design	47	53	348
III. Production	56	44	103
IV. Installation and operation	68	32	271
V. Sales and tendering	65	35	157
VI. Executive	73	27	247
VII. Teaching	-	-	6
VIII. General	88	12	17
IX. Computation	-	-	3
X . Patents and consulting	77	23	22

Table 3.2

Reasons (a) and (h) are intrinsic to the nature of the work but (b) to (g) are extrinsic and remediable. What is of interest here and relevant to the study of mathematics used by electrical-engineering technicians in South Africa is that 60% of design engineers, 80% of production engineers and 87% of installation and operation engineers never use mathematics. Most of the South African engineering-technician's job description is encompassed by these categories of work. Also 92% and 75% of non-use of mathematics is indicated by sales and executive staff respectively. It would appear from these results that because of the very high percentage of non-use of mathematics by the first group (design, production and installation) it would be in order if the nature of work is not considered as a parameter in the study of the use of mathematics by electrical technicians in the workplace and that we can expect the highest use from those technicians involved in design. Furthermore technicians are not trained by the technikons to fill a particular category of employment such as design, maintenance or installation. It is felt that more general approach would be expedient while responses by various categories of work will only be of academic interest. The U.K. study indicates under the general work category that 75% employees never use mathematics, 22% use mathematics sometimes and 3% of employees use mathematics often.

The second questionnaire related to the use of advance mathematics, a third questionnaire to the use of statistics and a final questionnaire on the use of computers. Furthermore, emanating from considerations with regard to relevance of mathematics, an electrical-engineering journal analysis was conducted. Nine journals, four British and five American, were analysed for its mathematical content. Topics occurring were scored per chapter. The weighted distribution per topic within a chapter was excluded by scoring a topic only once regardless of the number of times it occurs. The percentage occurrence per journal was then calculated.

Results on the use of statistics, the use of computers and the journal analysis is tabularised below:-

Results on the use of statistics, the use of computers and the journal analysis in tabularised below:

STATISTICAL CONCEPTS USED AND NATURE OF WORK

Percentages

STATISTICAL CONCEPTS USED	RESE ARCH AND DEV	DES IGN	PROD UCTI ON	INSTA LLATI ON	EXECU TIVE ADMIN	ALL GROU PS
DATA PROCESSING	69	63	66	62	72	67
COMPUTATIONS	85	67	69	70	70	74
DISTRIBUTIONS	72	48	69	45	47	55
SAMPLING DISTRIBUTIONS	30	19	21	13	13	21
HYPOTHESIS TESTING	11	5	15	4	4	8
ESTIMATION	10	18	9	4	19	13
METHODS	35	16	15	15	15	21
CORRELATION	24	11	25	19	8	17
REGRESSION	23	13	12	9	6	15
DESIGN OF EXPERIMENTS	19	4	19	4	6	10
ANALYSIS OF VARIANCE	16	4	12	9	6	9
MULTIVARIATE ANALYSIS	2	-		-	2	1
PROBIT ANALYSIS	5	-	-	-	-	2
PROBABILITY THEORY	16	17	-	19	19	17
STOCHASTIC PROCESSES	14	2	22	2	2	6
INFORMATION THEORY	47	25	-	19	15	28
TIME SERIES	31	31	25	26	34	31
RELIABILITY STUDIES	51	48	44	32	36	43
PROCESS CONTROL	16	15	75	26	26	24
ACCEPTANCE SAMPLING	15	15	56	17	19	19
PRODUCTION CONTROL	10	14	25	9	23	15
BUDGETARY CONTROL	8	28	25	40	64	28
ECONOMETRICS	1	2	6	-	4	2
MARKET RESEARCH	3	4	6	4	8	6
DECISION THEORY	7	1	3	-	2	3
OPERATIONS RESEARCH	8	25	28	23	26	21

Table 3.3

Question C 2: "Estimate the percentage of your time which is spent using statistical techniques."

Replies:

Percentage of time	< 1	1 to 5	5 to 10	10 to 20	>20.
Percentage of replies	12	35	28	13	4.

8 percent no reply

Question C 3: "How did you learn your statistics?"

Replies: Forty-eight percent replied that some statistics was included in the mathematics course for the degree, diploma or certificate;
fourteen percent attended an evening course in statistics;
three percent attended a full-time course in statistics;
thirty-eight percent acquired their knowledge of statistics by private study;
twenty-four percent stated other means of learning, such as working with a mathematician or statistician, attending a course in management studies;
four percent gave no reply.

These replies suggest that there is a demand for the training of engineers in statistics.

USE OF COMPUTERS

Nature of work	Percent using Computers	Percent not using Computers	N
Research and development	52	48	660
Design	32	69	839
Production	26	74	148
Installation and Operation	11	89	478
Sales	10	90	222
Executive Administration	24	76	419
Teaching	17	83	175
All groups	29	71	3031

Table 3.4

ANALYSIS OF BRITISH JOURNALS

	1	2	3	4	Total of 1 to 4
Reference number of journal	1	2	3	4	1 to 4
Number of articles examined	44	72	67	69	252

Subject matter	Percentage Frequencies				
1. No mathematics	50	67	19	38	43
2. Elementary mathematics only	27	13	25	9	17
Complex Variable, 3 to 5					
3. Conformal transformations			1		
4. Contour integration		1			
5. Power series, poles and zeros					
Ordinary Differential Equations, 6 to 8					
6. Classical methods	2	1	3	20	7
7. Laplace transform	2	3	1		2
8. Non-linear			4	3	2
9. Partial Differential Equations, classical methods	2		7	17	7
10. Fourier Series	5	4	1	1	3
11. Integral transorms and equations		1		3	1
12. Three-dimensional co-ord. geometry	2				
Optimisation of systems, 13 to 15					
13. Calculus of variations			1	4	2
14. Linear programming		1			
15. Other methods		3	1	1	2
16. Vector analysis	5		3		2
17. Hydro and aerodynamics				3	1
18. Elctro-mag. field theory			10	17	8
19. Matrices: manipulation	2	3	10	4	5
20. Matrices: eigenvalues				1	
21. Tensors			1	1	1
22. Boolean-algebra			1		
23. Theory of sets and groups					
24. Topology			4		1
25. Asymptotic expansions					
Special Functions, 26 to 28					
26. Bessel functions	2	3	6	10	6
27. Elliptic functions			3	1	1
28. Other special functions		1	3		1
Numerical Analysis, 29 to 32					
29. Approx. and curve fitting					
30. Systems of linear equations				1	
31. Ordinary diffl. equations				10	3
32. Partial diffl. equations			1	1	1
33. Use of digital computers	11		7	6	6
34. Use of analogue computers		1	1		1
35. Elementary probability		4	1	9	4
36. Statistics			3	1	1
37. Stochastic processes, time series, infn. theory			4	4	2
38. Other advanced topics	2	1	7	1	3

Table 3.5

ANALYSIS OF AMERICAN JOURNALS

	Subject matter	Percentage Frequencies					
	Reference number of journal	5	6	7	8	9	Total of 5 to 9
	Number of articles examined	152	131	66	112	58	519
1.	No mathematics	48	42	18	23	31	35
2.	Elementary mathematics only	33	27	21	17	2	23
	Complex Variable, 3 to 5						
3.	Conformal transformations	1	2	6	4	2	3
4.	Contour integration			2	5		2
5.	Power series, poles and zeros		1	2			
	Ordinary Differential Equations, 6 to 8						
6.	Classical methods	1	2	2	8	5	3
7.	Laplace transform	1	2	27	6		6
8.	Non-linear		1	9	3		2
9.	Partial Differential Equations, classical methods	2	1		3		1
10.	Fourier Series				7	5	2
11.	Integral transorms and equations		2	3	8	14	4
12.	Three-dimensional co-ord. geometry				1		
	Optimisation of systems, 13 to 15						
13.	Calculus of variations		1	3	1		1
14.	Linear programming						
15.	Other methods	3	2	5	2		2
16.	Vector analysis		2		2		1
17.	Hydro and aerodynamics						
18.	Elctro-mag. field theory	1	3	3	19	9	6
19.	Matrices: manipulation	3		14	13	16	7
20.	Matrices: eigenvalues			5	4	7	2
21.	Tensors				4	3	1
22.	Boolean-algebra	1	8		3		3
23.	Theory of sets and groups				2	3	1
24.	Topology				2	2	1
25.	Asymptotic expansions				3		1
	Special Functions, 26 to 28						
26.	Bessel functions	1			4	12	3
27.	Elliptic functions		1				
28.	Other special functions			2	2		1
	Numerical Analysis, 29 to 32						
29.	Approx. and curve fitting					3	
30.	Systems of linear equations				1		
31.	Ordinary diffl. equations				1		
32.	Partial diffl. equations	1		2	1		1
33.	Use of digital computers	9	2	3	10		6
34.	Use of analogue computers	1	2	8	4		3
35.	Elementary probability		1		3		1
36.	Statistics	1			1		1
37.	Stochastic processes, time series, infn. theory	1	5	5	11		4
38.	Other advanced topics						

Table 3.6

For the results on advanced topics which will occupy too much space, the reader is referred to

Scott, Brooks, Lee and Ramsay 1966

3.3 THE NORDIC REPORT ON MATHEMATICS AND ENGINEERS, SUMMARIZED BY HaSTAD, 1967

The Nordic Committee for the modernization of school mathematics, a joint effort by Denmark, Finland, Norway and Sweden, has, inter-alia investigated "Mathematics and Engineers" which was summarised by Matts Hastad (Hastad 1968). The investigation was divided into two parts. The first part dealt with the use of mathematics by engineers and technicians in a big Swedish industrial company. The second part dealt with mathematics required for the teaching of technical subjects in the technical gymnasiums in Sweden.

In the first part a stratified random sample of 150 engineers and technicians were picked including an even distribution of academic engineers (qualified at academic institutions) gymnasium engineers and technicians or unqualified engineers. By means of a questionnaire the use of mathematics in the workplace was determined. A table of the results are shown below:

	academic engineers	gymnasium engineers	technicians
algebra	75%	60%	50%
geometry	50%	30%	35%
calculus	50%	15%	15%
advanced mathematics	40%	3%	2%
mathematics of other type	30%	15%	7%

Table 3.7 (after Hastad, 1968,p.94)

Furthermore an analysis of the use of mathematics per category of work revealed that although the percentage use of mathematics varied substantially between calculating departments (planning, calculations, research and development) and other departments, the structure of needs was the same.

A further significant result was that no difference in use of mathematics was found when separating the engineers into age groups.

The use of mathematics in the industry by the gymnasium engineers was compared with the needs of mathematics in the study of technical subjects in the technical gymnasiums. A similar questionnaire with the same disciplines as in the "industry questionnaire" was answered by 127 teachers. Calculations of rank-correlation showed a similar structure as in the case of the engineers and technicians in the workplace.

3.4 A STUDY OF THE MATHEMATICS REQUIREMENT FOR ISRAELI TECHNICIANS AND PRACTICAL ENGINEERS, 1982

A study of the mathematics requirements for Israeli technicians and practical engineers was conducted by L.Berenson and B.Robinson of the Centre For Technological Education Holon, Israel, in 1982. (Berenson & Robinson 1983). The mathematics programme for Israeli technicians and practical engineers for electronics, electricity and control systems was examined in the light of their mathematical needs both while in college and in the workplace. The investigators were particularly interested firstly in the influence of modern technology such as computers on the mathematics used by technicians and practical engineers in industry. Secondly, the researchers were interested in the changes in the mathematics curriculum brought about by increasing technological sophistication.

The study utilized responsive evaluation and textbook analysis. It was found that while the mathematical needs of the sample group was generally met in the workplace, the utility value of classical mathematics was minimal. Furthermore the correlation between the formal study of mathematics at the colleges and its application to technical subjects was unsatisfactory. An increasing demand for boolean algebra, logic, algorithmic thinking, probability and statistics was revealed. There was a need for an early introduction of logic, simple matrices and determinants, boolean algebra and elementary differential equations with co-ordination between mathematics taught and its applications to technical subjects. The methodology involved interviewing personnel in key positions in eleven leading Israeli concerns. The interviews were aimed at determining the change in technology and the demand for manpower in relation to mathematics caused by these technological changes. The questions that were raised were:-

(i) What are the employment needs for mathematics?

(ii) What mathematical background is desirable for the technicians and practical engineers in the '80"s and

(iii) how will the increasing use of computers in industry influence the type of work performed by technicians and practical engineers?
Interviews with principals, department-heads and teachers of mathematics and technological subjects in three established technical colleges as well as the national inspector of these institutions attempted to provide the answers to the questions.

(iv) Does the mathematics programme at these colleges meet the mathematical needs of the students for their college study of technology?

(v) Is the mathematics studied at these colleges appropriate to the background of entering college students?

Another source of information was a comprehensive textbook analysis covering all the technical subjects studied in the technological colleges under investigation. The aim of the text analysis was to ascertain the mathematics underlying the technological subjects in the curriculum in order to establish whether the mathematics taught adequately covered these topics. Finally the response of the countries to the mathematical needs of their own electrical industry was studied and compared. These countries included England, Switzerland, Holland, U.S.A., Denmark, Sweden and Germany.

Interesting findings of the research were inter-alia:

(i) The ability to apply mathematics taught at college in the workplace was often lacking.

(ii) The majority of the companies agreed that although classical mathematics was still important as background its utility value in the workplace was constantly diminishing.

(iii) There was general agreement that the increasing use of computers would affect the work of the technician and the practical engineer. This indicated the need for subject matter such as boolean algebra, logic, flow charts and possibly numerical methods.

(iv) In order to understand the problems of systems planning and reliability a basic course in probability and statistics would be in order.

(v) About 2% of the industry under study and mainly those concerned with analog systems such as antennae and radar indicated a need for partial differential equations.

(vi) Advanced algebra and non-linear differential equations were not needed in the technological studies of technicians and practical engineers.

These findings amongst others indicated a weakness in the prescribed syllabi used in Israeli colleges.

3.5 **A SURVEY OF THE USE OF MATHEMATICS IN INDUSTRY IN HONG KONG, 1983**

This survey was conducted by W.K.Kam and H.P.Lo of the Departments of Mathematical studies of City Polytechnic and Hong Kong Polytechnic, Hong Kong, in 1983 (Kam and Lo 1983). The survey covered ten major industries in Hong Kong to determine the need for mathematics in industry (see table 3.8). Of interest is that 37 respondents to the questionnaire were connected to the electrical industry. Of these 17 were non-technical staff such as managers and accountants. It was found that there was a marked difference between the responses of the technical and non-technical staff. The technical staff were in a much better position to give information for which the survey was designed. Respondents were classified by the type of work they do such as research and development, design, sales, maintenance etc. (see table 3.10). Respondents, apart from being asked to provide input with respect to the use of mathematics in industry, were also asked to respond to the use of computers in industry.

The conclusions pertaining to all the industries surveyed indicated:

(i) A great variety of mathematical topics, including some quite advanced ones, have found some use. Twenty of the topics listed in Table 3.9 below have frequencies greater than 10.

(ii) Statistical and operations-research techniques are more useful than analytical methods.

(iii) Among the major industries, electrical, building and civil-engineering, electronics and machine-shop and metal-working, in descending order, use more mathematics than others.

(iv) The majority of technical staff are motivated to learn new mathematical topics required in their work.

(v) Building and civil-engineering, electronics, electrical, machine shops and metal working in that order used computers more than other industries (see table 3.11).

Industry	Number of respondents		
	Technical	Non-technical	Total
Automobile repairs and servicing	2	4	6
Building and civil-engineering	27	42	69
Clothing	24	320	344
Electrical	20	17	37
Electronics	40	35	75
Machine shop and metal-working	24	49	73
Plastics	12	63	75
Printing	2	12	14
Shipbuilding and ship repairs	1	2	3
Textile	19	51	70
TOTAL	171	595	766

Table 3.8 (after Kam and Lo, 1984, p.268)

Topic	Frequency	Relative frequency (per cent)
1. Elementary algebra, trigonometry and geometry	158	92
2. Elementary statistics	75	44
3. Statistical quality control	61	36
4. Elementary calculus	50	29
5. Numerical methods	44	26
6. Experimental design	37	22
7. Linear programming	32	19
8. Critical-path analysis	32	19
9. Queueing theory	26	15
10. Matrix methods	25	15
11. Vector methods	25	15
12. Statistical estimation and hypothesis testing	24	14
13. Time series and forecasting	23	14
14. Nonlinear equations	22	13
15. Ordinary differential equations	21	12
16. Market and opinion research	21	12
17. Decision theory	17	10
18. Calculus of variations	13	8
19. Regression and correlation	10	6
20. Simulation	10	6
21. Inventory control	9	5
22. Partial differential equations	8	5
23. Laplace transforms, Z transforms, Fourier transforms	8	5
24. Special functions	8	5
25. Functions of a complex variable	7	4
26. Nonlinear and dynamic programming	7	4
27. Statistical multivariate analysis	6	4
28. Tensors	5	3

Table 3.9 (after Kam and Lo, 1984, p.268)

Topic	Number and percent of technical respondents according to nature of work											
	Research and Development		Design		Sales and maintenance		Manufacturing		Computation information processing		Others	
	n	(percent)	n	(percent)		(percent)	n	(percent)	n	(percent)	n	(percent)
Elementary algebra	37	(100)	73	(100)	22	(81)	97	(92)	22	(100)	18	(90)
Trigonometry and geometry												
Elementary statistics	23	(62)	29	(40)	11	(41)	49	(47)	15	(68)	11	(55)
Statistical quality control	21	(51)	27	(37)	10	(37)	43	(41)	10	(45)	5	(25)
Elementary calculus	15	(41)	32	(44)	5	(19)	26	(25)	6	(27)	6	(30)
Numerical Methods	13	(35)	22	(30)	6	(22)	21	(20)	7	(32)	8	(40)
Experimental design	17	(46)	21	(29)	5	(19)	20	(19)	8	(36)	4	(20)
Linear programming	12	(32)	17	(23)	7	(26)	16	(15)	6	(27)	7	(35)
Critical-path analysis	10	(27)	14	(19)	6	(22)	16	(15)	7	(32)	10	(50)

Table 3.10 (after Kam and Lo, 1984,p.271.)

USE OF COMPUTERS

	Yes		No	
Industry	n	(%)	n	(%)
Building and civil-engineering	13	(48)	14	(52)
Electronics	16	(40)	24	(60)
Electrical	6	(30)	14	(70)
Machine shop and metal-working	6	(25)	18	(75)
Clothing	3	(13)	21	(87)
Textile	1	(5)	18	(95)
Automobile repairs and servicing	0	(0)	17	(100)
plastic, printing, shipbuilding and ship repair				
Total	45	(26)	126	(74)

Table 3.11 (after Kam and Lo, 1984, p.273.)

3.6 MATHEMATICAL REQUIREMENTS OF TECHNICAL ENGINEERS (IN SOUTH AFRICA), 1987

In 1987 the mathematical requirements of technical engineers was investigated by J Strauss and R M Diab in South Africa in order to evaluate the current mathematical curriculum at South African technikons with the purpose of determining the mathematical requirements of technikon students while at the technikon and in industry. (Strauss & Diab, 1988)

A questionnaire was distributed to diplomates, staff of electrical, electronic, mechanical and civil-engineering departments. Of the original 387 questionnaires which reached their destination, 98 were returned which represented a 25,3% return, 32% of which were from the electrical-engineering field. Two significant results were that (i) qualification of the respondent in the workplace played no major part in the determination of the mathematics used in the workplace and (ii) that the difference between the requirements for the different disciplines in engineering was enough to warrant a branched sequence structure in the syllabuses at all levels of instruction. This means that whilst certain mathematical topics receive support from all engineering fields other topics show a clear differential in needs.

3.7 **SUMMARY**

All five studies made use of questionnaires to extract data from engineers and/or technicians in the workplace. Nature of work, qualification and age had very little or no significant effect on the outcomes of those surveys which tested these parameters. Some surveys found that the use of classical methods in the workplace is diminishing in importance in favour of numerical and statistical methods. The text analysis of the Israeli study and the journal analysis of the U K study yielded valuable additional information. The Nordic, Israeli and South African studies additionally elicited the opinions of academic staff on the need for mathematics in engineering and/or technician-training programmes.

CHAPTER 4

RESEARCH METHODOLOGY

4.1 INTRODUCTION

In this chapter the purpose of the study, the methodology and the limits of the study will be expounded giving details on formulation of the questionnaire, a text analysis, and a work-group. All of which form a system of mechanisms to extract data in an attempt to solve the problem of revising the present engineering-mathematics syllabi at technikons in the face of changing technology.

4.2 THE PURPOSE OF THE STUDY

This research will attempt to identify the mathematics-content needs for engineering-mathematics as instructional-offering in the electrical-engineering instructional-programme at technikons. The identification of mathematics content will take place in both the theoretical and in- service components of technician training with due regard for the members participating in the training process. These members are the lecturer, the technicians and the engineer. Although there are many relevant factors and needs impinging on the performance of the student, the scope of this survey does not allow for elaboration on these factors and needs.

It can therefore be said that the purpose of this study is to determine the content for engineering-mathematics syllabi in terms of the co-operative-education philosophy espoused by technikons in the R.S.A.

4.3 METHODOLOGY

This research consists of several components. Firstly, a literature search was conducted to give an overview with respect to:

(i) A historical background to technikons

(ii) Co-operative Education as the for technikon educational philosophy
(iii) Curriculum design models
(iv) Instructional-offerings of the electrical-engineering instructional-programmes
(v) Relevant research

This literature search appears in the previous three chapters and forms the basis for a structure to extract the mathematics content from the theoretical and in- service components of the technicians training.

The positive results obtained by the Israeli survey in chapter 3 has influenced the methodology of this survey to include as data- extracting mechanisms a questionnaire and a text analysis (Berensen and Robinson 1983).

Finally a work-group, representative of all technikons in South-Africa, was formed under the chairmanship of the researcher in order to propose concept syllabi for engineering-mathematics offered at technikons. The proposals were based on the opinions of technikon lecturers. The mandate for the formation of this work-group was obtained from a fully representative technikon-mathematics conference held in Scottburgh, Natal in September 1987 (Swanepoel 1987).

The analysis of the data from the questionnaire and text analysis will be compared with the concept syllabi proposed by the work-group in order to support or reject part or whole of the concept syllabi. This support or rejection of the syllabi proposed by the work-group will form part of the research based recommendations in the final chapter.

4.4 LIMITS OF THE STUDY

4.4.1 THE THEORETICAL COMPONENT OF TECHNICIAN TRAINING

The study will only concentrate on the mathematical needs for the theoretical training of National Diploma and National Higher Diploma students in Electrical-Engineering at the Peninsula

Technikon. This means that, only the text references of instructional-offerings at the Peninsula Technikon will be considered for text analysis.

4.4.2 THE IN-SERVICE COMPONENT OF TECHNICIAN TRAINING

The research will only involve the technicians and engineers of the major electrical-engineering institutions which employ Peninsula Technikon diplomates.

4.4.3 LECTURERS' OPINION

The opinion of the lectures of engineering-mathematics and other instructional-offerings within the instructional-programme will be extracted in a manner which will ensure country-wide representation.

4.5 THE QUESTIONNAIRE

4.5.1 RATIONALE

1. The definition of co-operative education compels us to look at any instructional-offering, at any institution espousing the philosophy of co-operative education, in terms of its effectiveness in the theoretical curriculum as well as in the workplace experience. "Co-operative Education involves the technikon and industry as partners in the formulating of the educational programme qualifying students for employment in industry .....the experience (workplace) component is an extension of the formal component (theory and laboratory practice) of the education of a technikon student."

2. If this investigation should indicate any shortcomings in mathematics as a supporting instructional-offering in the electrical-engineering curriculum, then any corrections will have to considered in terms of the strategies of an acceptable curriculum design model. The proposed model for this study is that of Kruger as adapted for technikon-mathematics. This study will be concerned with only three of the Kruger-model's six steps viz.:-

(i) A situation analysis the aim of which is to firstly determine what mathematics is used by the instructional-offerings other than engineering-mathematics in a course. Secondly mathematics topics used in related industry (electrical-engineering) will be determined.

(ii) The selection of learning experiences which will be extracted from the information obtained by the situation analysis.

(iii) Structuring of content of engineering-mathematics syllabi will be proposed. In selection and structuring of content one has the keep the aims of mathematics as set out in pages 16 and 17 in mind.

3. A study of relevant research as depicted and summarised in chapter 3, indicates the following points to be built into the rationale of this study:-

(i) Predominant use of pre-coded questionnaires which exclude comments should be avoided (Scott et. al 1965).

(ii) The nature of work within a discipline does not influence the use of mathematics significantly (Strauss and Diab 1987). However, for large firms it is necessary for stratified sampling in order to claim representativeness of the survey respondents. For smaller companies it will be expedient to identify and get the co-operation of all mathematics users.

4. Although the opinion of lecturers on the mathematics required to support the serviced instructional-offerings in a curriculum is acceptable, a more precise verification of such opinion can be obtained from a comprehensive textbook analysis of the kind conducted in the Israeli study (Berensen and Robinson 1983). To this can be added the mathematical needs of industry to complete the investigation into demands on mathematics.

5. Preliminary interviews with managers on the relevance of mathematics indicated that engineers would like technicians to become more involved in calculations.

4.5.2 STRUCTURE

Based on the above foundation the questionnaire (appendix 1) has been designed to give the following information:-

(i) An indication of the frequency of the use of mathematics topics by both engineers and technicians in electrical-engineering.
(ii) The geographical location of the workplace.
(iii) The age of the respondent.
(iv) Indications of use of computers by respondents.
(v) Examples of calculations used by engineers and technicians in the categories Soften, occasionally, rarely, not at all.
(vi) The rating by the respondent of the utility value of classical mathematics, Boolean-algebra, numerical methods, statistics and any other on a scale of 1-10 (10-very high utility value).
(vii) An indication of the acceptance of the present mathematics syllabi at technikons by engineering-technicians.
(viii) The respondents' opinions on any change in mathematics needed for the future (a trend opinion).
(ix) The engineers' opinions on the extent of involvement expected from technicians in calculations at present performed by the engineers.
(x) Any relevant comments.

The questionnaire does allow a fair amount of freedom of response which make it necessary not to choose the sample too large. This should keep the information to be processed within reasonable limits.

The questionnaire is specifically not bilingual to keep it short. The home language of the respondent was not known beforehand with the result that all questionnaires posted were in the English language which seems to be the best risk due to the fact that technical language is still predominantly English in the Republic of South Africa. This assumption is not based on any census data but on the well-known fact that most of the technical books are printed in the English language.

4.6 THE TEXT ANALYSIS

The text analysis is based on the Israeli survey (Berenson and Robinson 1983). The following strategy was used:-

(i) The 1989/1990 prospectus for the school of electrical-engineering was used to identify all instructional-offerings in electrical-engineering.

(ii) The electrical department supplied the researcher with a list of text references.

(iii) Syllabi and lecturers guides (where in existence) were obtained from the electrical department in order to identify the topics for each instructional-offering as well as an indication of the depth to which each topic is prescribed.

(iv) Prescribed topics were identified in the text references.

(v) Identified topics in text references were then scored for mathematical content.

(vi) Mathematical content were identified in terms of mathematical topics used in a relevant chapter making sure that a topic is only counted once although it may occur more than once in that chapter.

(vii) The chapter and page number of the mathematical topic occurring is recorded.

(viii) The frequency of occurrence of mathematics topics per semester of study is cross-tabulated.

(ix) A list of mathematics topics cross-tabulated against instructional-offerings is obtained.

(x) All of the above is done separately for each level of study (i.e. T1, T2, T3 and T4).

A weakness here is that "lecturers' guides" were not consistent in the type of information given. The types of information which are important are :-

(a) the depth of each topic indicated by referring to the text chapter and pages,

(b) the timing of each topic in the academic semester. In other words when is the topic taught.

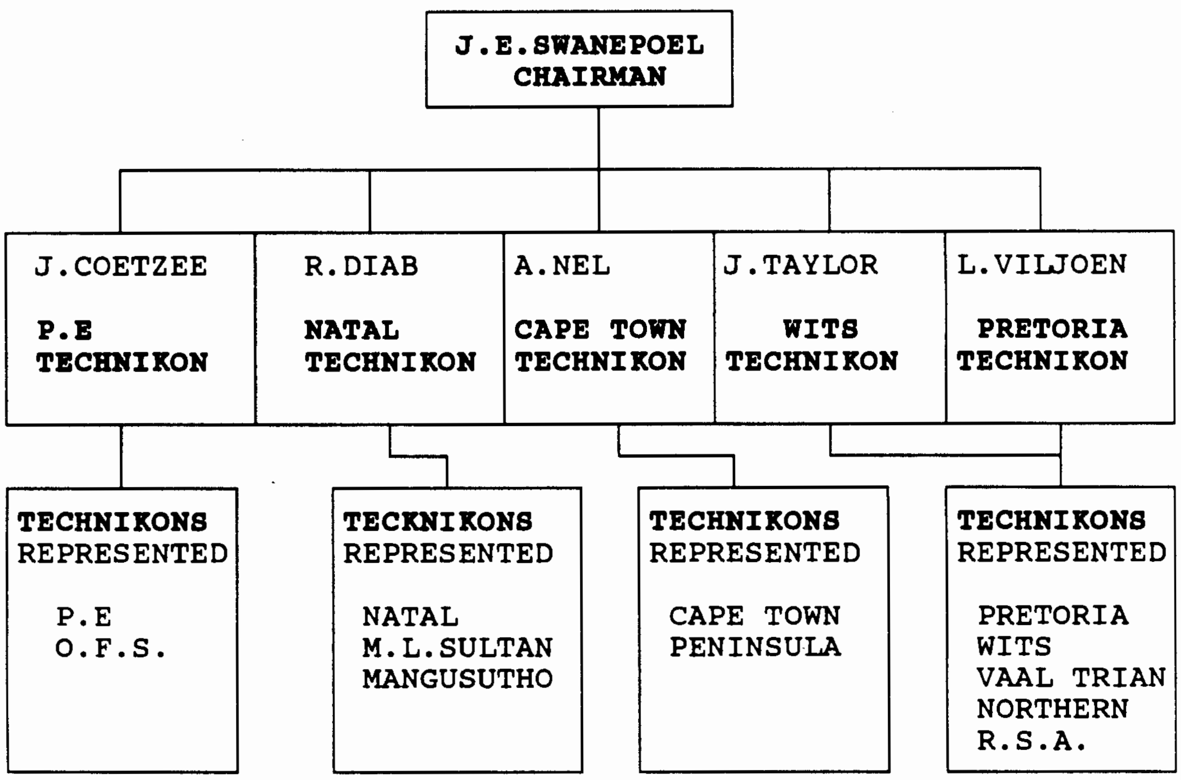
The latter type of information was incomplete in most cases whereas the former type were absent from some lecturers' guides.

4.7 THE STRUCTURED WORK GROUP (PANEL) FOR DETERMINING THE OPINION OF THE MATHEMATICS AS WELL AS ELECTRICAL-ENGINEERING LECTURES AT ALL TECHNIKONS OF THE R.S.A.

The work-group was led by the researcher and was comprised of five area representatives who were mathematics lecturers. The five members (excluding the researcher) represented the technikons as follows:-

4.7.1 COMPOSITION

REPRESENTATION ON PANEL



Each member had to liaise with the technikons in his area in order to extract the mathematics required by the mathematics lecturers as well as the lecturers in the other engineering instructional-offerings.

4.7.2 CRITERIA ADOPTED

The work-group adopted the following criteria for formulating syllabus changes (only the criteria relevant to the research is quoted). (Swanepoel 1987 p.2).

1. Syllabi should differentiate between various disciplines. (Science, Civil-Engineering, Electrical-Engineering and Mechanical-Engineering).

2. Syllabi should be pitched at a level which is compatible with the entry level of the student.

3. Syllabi should take into consideration the need of the theoretical offerings as well as that of industry.

The above criteria compare favourably with course-content selection criteria advocated in paragraph 2.4(c).

Final concept syllabus proposals were formulated together with a full set of lecturers' guides indicating depth and timing (see appendix 3). For the purposes of this survey criterium 3 is important and will be used to evaluate the proposed syllabi against the findings based on the questionnaire and text analysis.

CHAPTER 5

THE USE OF MATHEMATICS BY ENGINEERS AND TECHNICIANS IN THE WORKPLACE : RESULTS OF THE SURVEY

5.1 INTRODUCTION

Using the questionnaire data the sample distribution will be discussed. The respondent profile will be elaborated on in terms of area distribution, employment-category distributions and age distribution. These elements of the profile serve as indicators of representativeness of the sample of respondents. The employment categories will be collapsed into two main categories viz. engineers and technicians. These two categories will then be compared in terms of their use of mathematics in the workplace as well as their use of computers. Data will be extracted to indicate engineers' desire to involve technicians in the execution of their calculations. Finally the engineers' and technicians' notions on a suitable technikon-mathematics syllabus to serve the future will be listed.

5.2 SAMPLE PROFILE

Ninety (90) questionnaires were posted to seven (7) electrical-engineering institutions. Responses were received from all institutions. The geographical areas covered were Transvaal with two large institutions and the Cape with five small companies. The largest institution had a wide range of specialization which included:

Power-engineering investigations,
Specialist-materials investigations,
Specialist-mechanical investigations,
High-voltage investigations,
Process-control and environmental investigations,
Plant-integrity and performance investigations,
Specialist-chemical investigations, and
Plant-performance investigations.

Sampling for this institution was done on a random basis using a discrete uniform probability density function. Also stratified sampling was used in order to get respondents from all the sections above.

The ninety questionnaires posted generated 74 responses of which one was spoilt.

85,2% of the respondents were from the Transvaal and
14,8% from the Cape (see figure 5.1).
35,6% of the respondents were engineers ;
4,1% were lecturers in industry ;
4,1% were managers and
56,2% of the respondents were technicians (see figure 5.2).

On the basis of the finding of previous investigations which indicated that the job specialization within a category of work (electrical engineers) did not influence the spectrum of mathematical needs in industry, the above categories were collapsed into two basic categories viz.

engineers	32 respondents
technicians	41 respondents

The following frequency histograms indicate

(i) the age distribution of the sample (figure 5.3)

(ii) the age distribution of the technicians (figure 5.4)

(iii) the age distribution of the engineers (figure 5.5)

One can glean from these figures that the sample respondents represented an age range between 20 years and 60 years which does not favour a specific age group.

AREA DISTRIBUTION OF RESPONDENTS

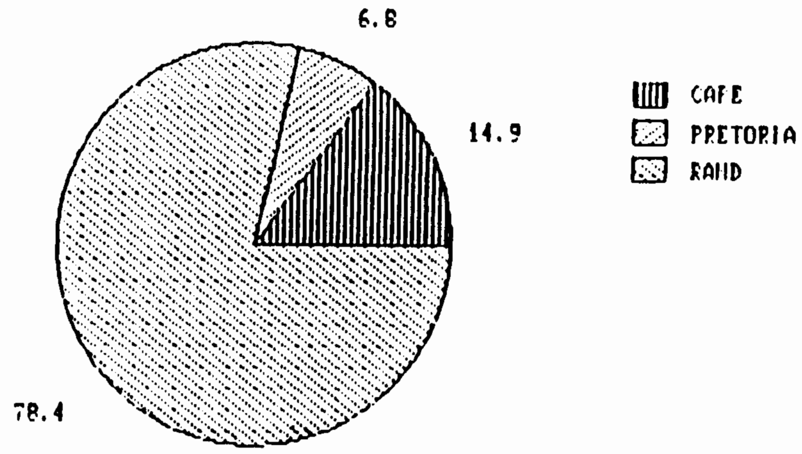


Table 5.1

DIVISION OF RESPONDENTS

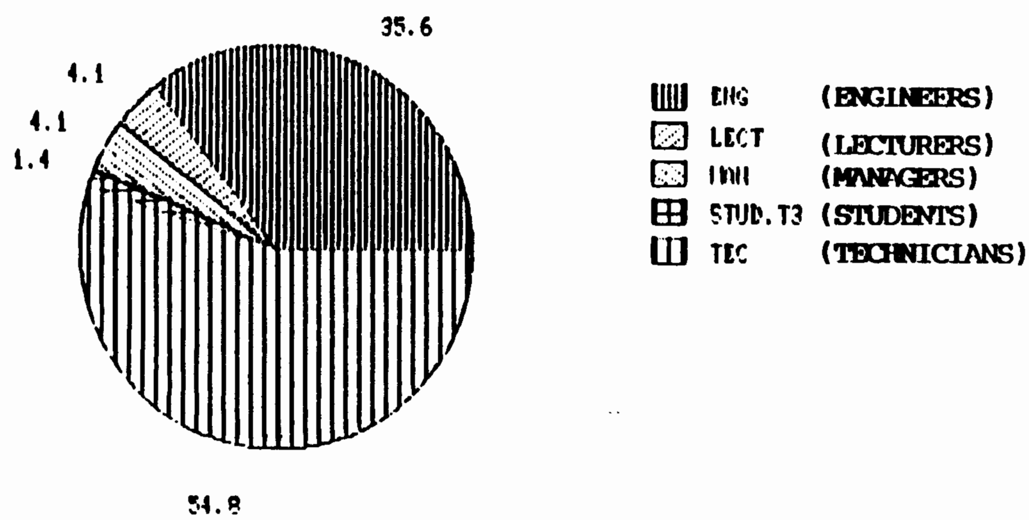


Table 5.2

AGE DISTRIBUTION FOR FULL SAMPLE

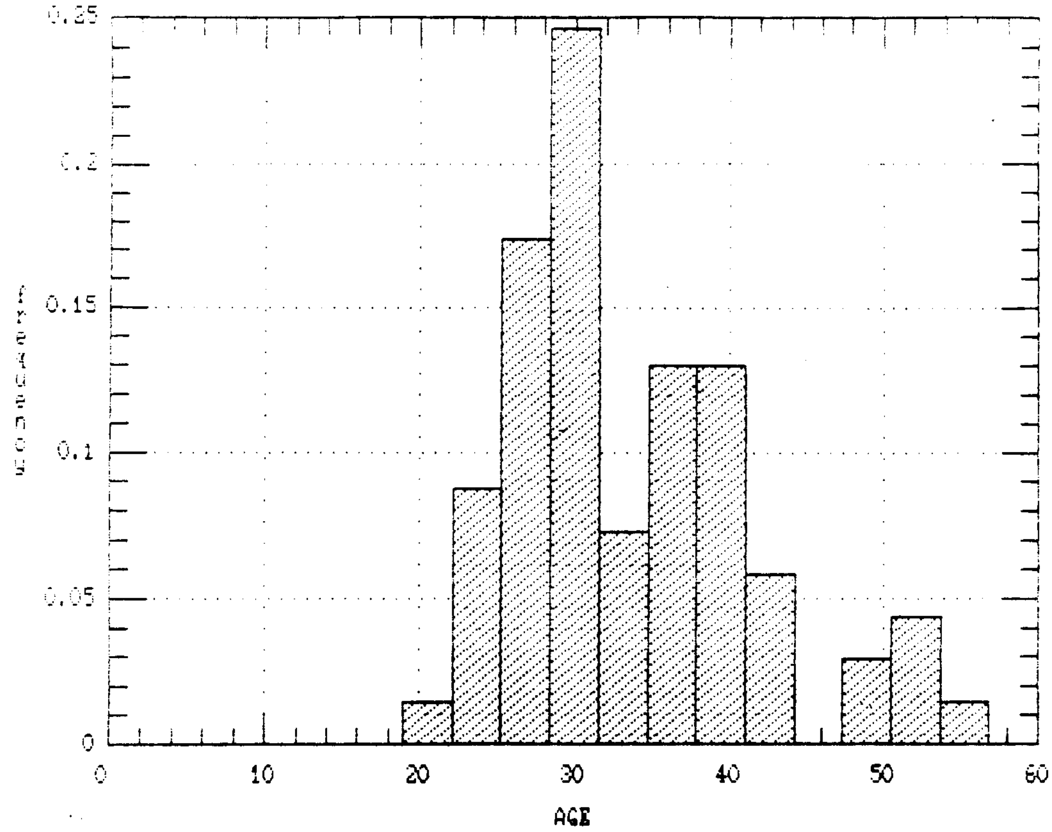


Table 5.3

AGE DISTRIBUTION FOR TECHNICIANS

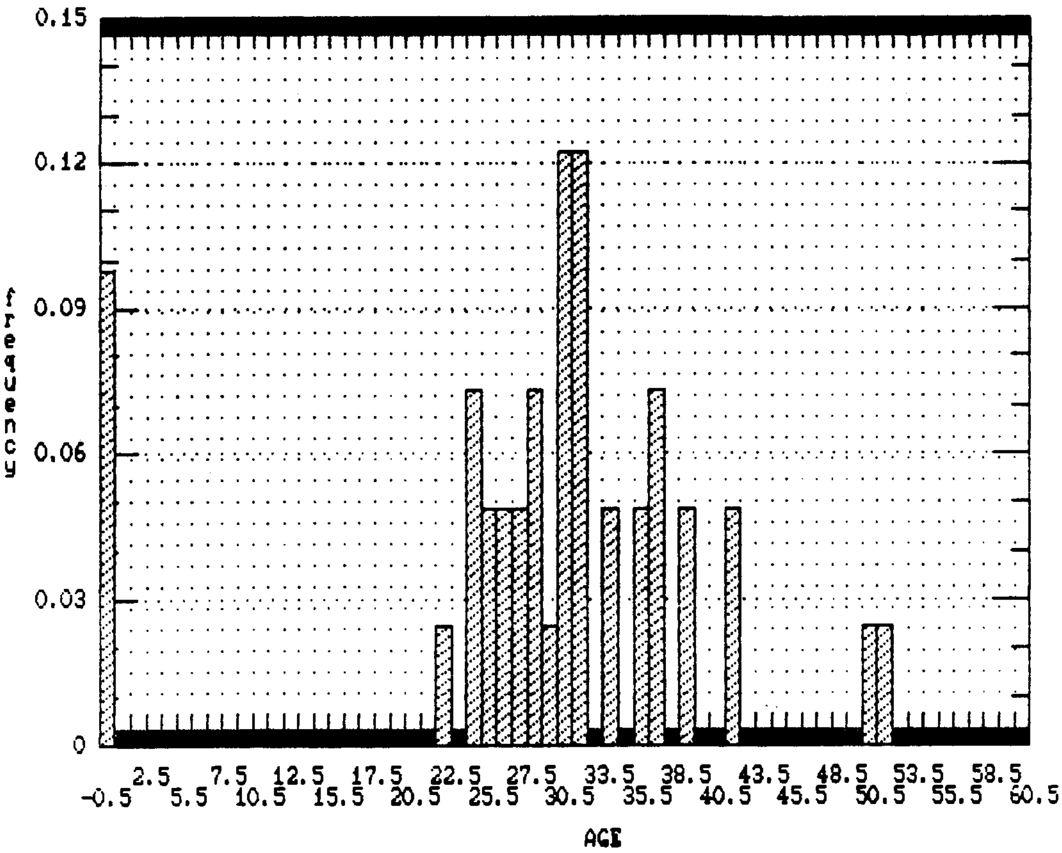


Table 5.4

AGE DISTRIBUTION FOR ENGINEERS

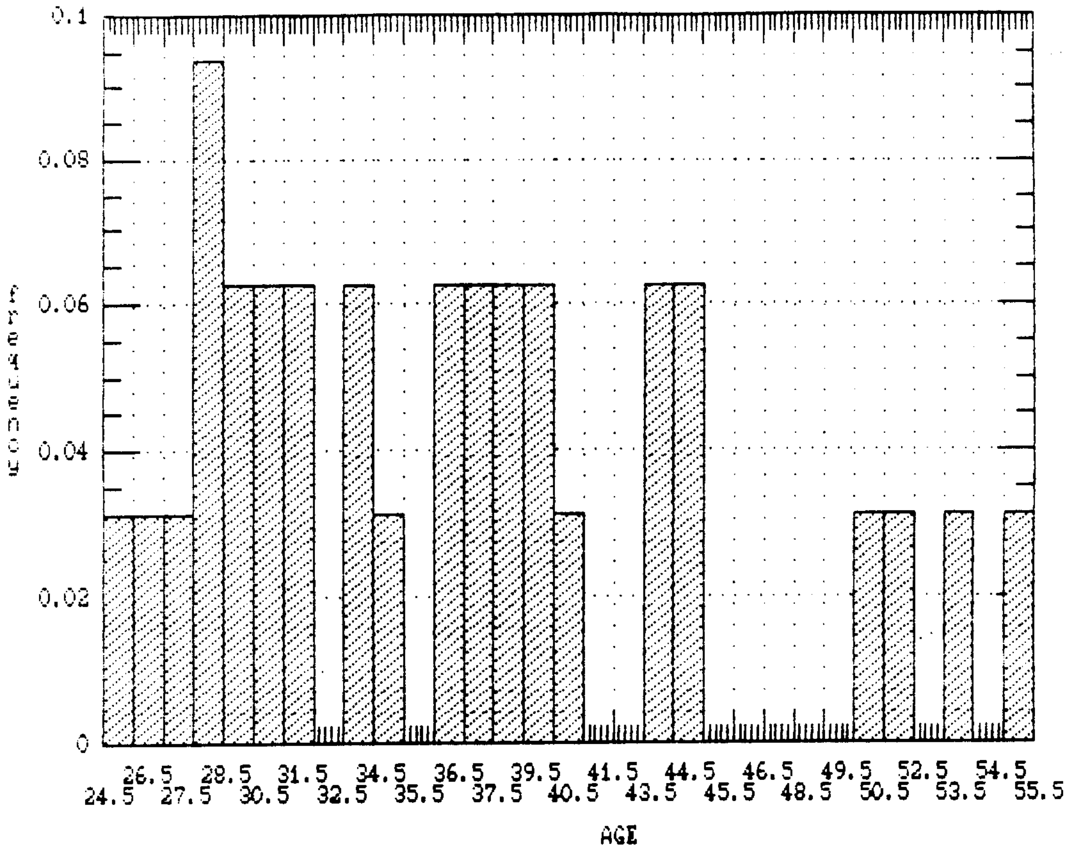


Table 5.5

5.3 FREQUENCY OF USE OF MATHEMATICS BY ENGINEERS AND TECHNICIANS IN THE WORKPLACE

The table below is a cross-tabulation indicating the frequency of use of mathematics topics in the calculations by engineers and technicians (table 5.6).

COMPLEX NUMBERS	DEFAULT	NEVER	RARELY	OCCA-SIONAL	OFTEN	ROW TOTAL
ENGINEERS %	1 3.1	14 43.8	4 12.5	6 18.8	7 21.9	32
TECHNICIANS %	0 0	25 61.0	6 14.6	5 12.2	5 12.2	41

Table 5.6a

TRIG-FUNCTION	DEFAULT	NEVER	RARELY	OCCA-SIONAL	OFTEN	Row Total
Engineers	1	5	5	14	7	32
%	3.1	15.6	15.6	43.8	21.9	43.8
Technicians	0	17	6	9	9	41
%	.0	41.5	14.6	22.0	22.0	56.2
HYPERBOLIC-FUNCTIONS	DEFAULT	NEVER	RARELY	OCCA-SIONAL	OFTEN	
Engineers	1	18	7	5	1	32
%	3.1	56.3	21.9	15.6	3.1	43.8
Technicians	2	27	7	4	1	41
%	4.9	65.9	17.1	9.8	2.4	56.2
DIFFEREN-TIATION	DEFAULT	NEVER	RARELY	OCCA-SIONAL	OFTEN	
Engineers	2	10	9	9	2	32
%	6.3	31.3	28.1	28.1	6.3	43.8
Technicians	3	25	7	4	2	41
%	7.3	61.0	17.1	9.8	4.9	56.2
PARTIAL DIFFEREN-TIATION	DEFAULT	NEVER	RARELY	OCCA-SIONAL	OFTEN	
Engineers	1	21	7	2	1	32
%	3.1	65.6	21.9	6.3	3.1	43.8
Technicians	1	34	4	2	0	41
%	2.4	82.9	9.8	4.9	.0	56.2
O.D.E.'S	DEFAULT	NEVER	RARELY	OCCA-SIONAL	OFTEN	
Engineers	1	17	5	9	0	32
%	3.1	53.1	15.6	28.1	.0	43.8
Technicians	1	33	5	2	0	41
%	2.4	80.5	12.2	4.9	.0	56.2
P.D.E.'S	DEFAULT	NEVER	RARELY	OCCA-SIONAL	OFTEN	
Engineers	1	23	5	3	0	32
%	3.1	71.9	15.6	9.4	.0	43.8
Technicians	1	35	3	2	0	41
%	2.4	85.4	7.3	4.9	.0	56.2

Table 5.6.b

BOOLEAN ALGEBRA	DEFAULT	NEVER	RARELY	OCCA-SIONAL	OFTEN	Row Total
Engineers	1	8	9	7	7	32
%	3.1	25.0	28.1	21.9	21.9	43.8
Technicians	0	18	5	11	7	41
%	.0	43.9	12.2	26.8	17.1	56.2

NUMERICAL METHODS	DEFAULT	NEVER	RARELY	OCCA-SIONAL	OFTEN	
Engineers	1	7	8	9	7	32
%	3.1	21.9	25.0	28.1	21.9	43.8
Technicians	1	25	4	2	9	41
%	2.4	61.0	9.8	4.9	22.0	56.2

STATISTICS	DEFAULT	NEVER	RARELY	OCCA-SIONAL	OFTEN	
Engineers	2	8	7	14	1	32
%	6.3	25.0	21.9	43.8	3.1	43.8
Technicians	1	18	6	12	4	41
%	2.4	43.9	14.6	29.3	9.8	56.2

INDICES	DEFAULT	NEVER	RARELY	OCCA-SIONAL	OFTEN	
Engineers	1	10	5	8	8	32
%	3.1	31.3	15.6	25.0	25.0	43.8
Technicians	2	23	5	9	2	41
%	4.9	56.1	12.2	22.0	4.9	56.2

LOGARITHMS	DEFAULT	NEVER	RARELY	OCCA-SIONAL	OFTEN	
Engineers	1	4	13	8	6	32
%	3.1	12.5	40.6	25.0	18.8	43.8
Technicians	2	14	8	9	8	41
%	4.9	34.1	19.5	22.0	19.5	56.2

VECTORS	DEFAULT	NEVER	RARELY	OCCA-SIONAL	OFTEN	
Engineers	1	8	9	7	7	32
%	3.1	25.0	28.1	21.9	21.9	43.8
Technicians	1	21	6	8	5	41
%	2.4	51.2	14.6	19.5	12.2	56.2

Figure 5.6.c

MATRICES	DEFAULT	NEVER	RARELY	OCCA-TIONAL	OFTEN	Row Total
Engineers	1	11	10	6	4	32
%	3.1	34.4	31.3	18.8	12.5	43.8
Technicians	1	30	4	4	2	41
%	2.4	73.2	9.8	9.8	4.9	56.2

Table 5.6d

FREQUENCY OF RATINGS FOR STATISTICS

	0	1	2	3	4	5	6	7	8	9	10
ENGINEERS	2	4	2	2	1	4	4	4	4	3	2
%	6.3	12.5	6.3	6.3	3.1	12.5	12.5	12.5	12.5	9.4	6.3
TECHNICIANS	6	9	0	8	3	5	1	4	4	1	0
%	14.6	22.0	.0	19.5	7.3	12.2	2.4	9.8	9.8	2.4	.0

Table 5.7

FREQUENCY OF RATINGS FOR CLASSICAL MATHS

	0	1	2	3	4	5	6	7	8	9	10	Row Total
ENGINEERS	2	1	2	0	0	7	3	3	7	4	3	32
%	6.3	3.1	6.3	.0	.0	21.9	9.4	9.4	21.9	12.5	9.4	43.8
TECHNICIANS	5	5	1	2	6	3	0	4	6	0	9	41
%	12.2	12.2	2.4	4.9	14.6	7.3	.0	9.8	14.6	.0	22.0	56.2

Table 5.8

0 = very low rating
10 = very hig rating

FREQUENCY OF RATINGS FOR BOOLEAN ALGEBRA

	0	1	2	3	4	5	6	7	8	9	10	Row Total
ENGINEERS	2	1	6	4	2	4	1	3	4	1	4	32
%	6.3	3.1	18.8	12.5	6.3	12.5	3.1	9.4	12.5	3.1	12.5	43.8
TECHNICIANS	4	14	1	1	2	2	1	3	7	1	5	41
%	9.8	34.1	2.4	2.4	4.9	4.9	2.4	7.3	17.1	2.4	12.2	56.2

Table 5.9

FREQUENCY OF RATINGS FOR NUMERICAL ALGEBRA

	0	1	2	3	4	5	6	7	8	9	10	
ENGINEERS	2	3	2	2	3	6	1	2	2	4	5	32
%	6.3	9.4	6.3	6.3	9.4	18.8	3.1	6.3	6.3	12.5	15.6	43.8
TECHNICIANS	7	11	6	2	4	1	2	1	2	3	2	41
%	17.7	26.8	14.6	4.9	9.8	2.4	4.9	2.4	4.9	7.3	4.9	56.2

Table 5.10

0 = very low rating
10 = very high rating

The frequencies of use per mathematics topic (table 5.6) is depicted in cells representing the job category (engineer/technician) by a rank category (never-, rarely-, occasionally- and often-used calculations). Provision is made for a default column catering for non-responses. Table 5.11 which lists the topics for use in the workplace has been compiled after sorting the frequencies in the "never-use" cells of tables 5.6.

MATHEMATICS TOPICS USED IN THE WORKPLACE : PRIORITY LIST

	ENGINEERS	TECHNICIANS
1	Logarithms	Logarithms
2	Trig-functions	Trig-functions
3	Numerical methods	Statistics
4	Boolean-algebra	Boolean-algebra
5	Vectors	Vectors
6	Statistics	Indices
7	Differentiation	Numerical methods
8	Indices	Complex numbers
9	Matrices	Differentiation
10	Complex numbers	Hyperbolic functions
11	O.D.E.'s	Matrices
12	Hyperbolic functions	O.D.E.'s
13	Partial differentiation	Partial differentiation
14	P.D.E.'s	P.D.E.'s

(Table 5.11)

Where these cells had the same value the OFTEN-USED cells were sorted for those topics to decide priority. The striking similarity between these lists is significant in the sense that it confirms the conclusion in previous surveys, discussed in chapter 3, that job designation in electrical-engineering has no or little effect on the spectrum of mathematics required by those in the workplace (Strauss and Diab 1988). Furthermore it is significant to note that of the first seven topics there are four topics not appearing in the engineering-mathematics syllabi presently (1989) in use in technikons (see appendix 2). These high-priority topics are numerical methods, Boolean-algebra, vectors and statistics.

The topic list seems to be complete if one takes into consideration that no respondent listed any additional topics in the space provided in the questionnaire (appendix 1, Question 1.16).

Analysis of the control question (tables 5.7-10) asking respondents to rate classical mathematics, Boolean-algebra, numerical methods, statistics and a topic of their own choice in terms of its utility value on a scale of 1-10 (10-very high utility), has shown the following priority:

ENGINEERS	TECHNICIANS
Classical mathematics	Classical mathematics
Numerical methods	Boolean
Statistics	Statistics
Boolean-algebra	Numerical methods

Table 5.12

The above list has been compiled from tables 5.7 - 5.10 by multiplying rating by frequency and adding row-wise yielding the following scores:

TOPIC	ENGINEERS	TECHNICIANS
Classical mathematics	629	532
Boolean-algebra	503	436
Numerical methods	562	322
Statistics	533	400

Table 5.13

These scores were then sorted in descending order to determine a priority list (table 5.12) for each category.The high rating of classical mathematics in both categories (engineers and technicians) seems to partly refute the rating in table 5.11.

This phenomenon could possibly be due to a weakness in the questionnaire in that no explanation was given as to what classical mathematics is. Another explanation could be that distortions occurred in the rating of Boolean-algebra, numerical methods and statistics causing classical mathematics to be deposed. A check on correlation (using Spearman Rank correlation) between the use of above topics i.e. Boolean-algebra, numerical methods and statistics and their rating indicates a high correlation (0.60+) for technicians. For engineers there is a moderate(0.40 to 0,59) correlation for numerical methods and Boolean-algebra and a high correlation for statistics. However, a check on correlation between use of topics such as complex numbers, trigonometric functions, differentiation, integration, O.D.E.'s, P.D.E.'s, vectors and matrices and the rating of classical mathematics yields a low to moderate correlation (see tables 5.14 - 5.15).

Two explanations are now possible:

1. The problem lies with the interpretation of classical mathematics. This is highly unlikely in terms of the academic background of engineers and technicians.

2. That classical mathematics still enjoys a high priority as background whilst its utility value has given way to numerical methods, Boolean-algebra and statistics.

The latter explanation is more acceptable and finds resonance in the Israeli survey (Berenson and Robinson 1983).

SPEARMAN RANK CORRELATIONS
BETWEEN RATING AND USE OF
TOPICS BY ENGINEERS (SAMPLE SIZE = 32)

MATHEMATICS TOPIC USE	CLASSICAL MATH RATING	BOOLEAN ALGEBRA RATING	NUMERICAL METHODS RATING	STATISTICS RATING
Complex numbers	.2076			
Trigonometric functions	.2536			
Hyperbolic functions	.2944 .1012			
Differentiation (ordinary)	.1883			
Integration	.1759			
Differentiation (partial)	.1726			
Ordinary Diff. equation	.3203			
Partial diff. equation	.2776			
Boolean algebra		.4723		
Numerical methods			.4950	
Statistics				.5831
Logarithms	.1281			
Vector analysis	.1983			
Matrix algebra	.2360			

Table 5.15

SPEARMAN RANK CORRELATIONS
BETWEEN RATING AND USE OF
TOPICS BY TECHNICIANS (SAMPLE SIZE = 41)

MATHEMATICS TOPIC USE	CLASSICAL MATH RATING	BOOLEAN ALGEBRA RATING	NUMERICAL METHODS RATING	STATISTICS RATING
Complex numbers	.4462			
Trigonometric functions	.4532			
Hyperbolic functions	.2044			
Differentiation (ordinary)	-.0587			
Integration	.0714			
Differentiation (partial)	.1574			
Ordinary Diff. equation	.2922			
Partial diff. equation	.1894			
Boolean algebra		.8206		
Numerical methods			.6468	
Statistics				.6440
Logarithms	.2034			
Vector analysis	.3873			
Matrix algebra	.1803			

Table 5.14

5.4 THE USE OF COMPUTERS BY ENGINEERS AND TECHNICIANS

THIRTY-FIVE (48%) of the respondents indicated the use of a personal computer. Whilst only FOUR (5%) used a main frame computer. FORTY (55%) are making use of hand-held calculators. All hand held calculators used are of the programmable type. The types of P.C.s used are Cyber 865, IBM, HP 9836 and 98450 , Sperry, Sharp 1500P, Fluke and IBM Compatible.

Software used are:

1 Lotus 123
2 D Base III
3 Apollo Domain
4 DATA logger and expounder
5 Exorset Div. system
6 Kontron Devl system
7 Autocad and Turbocad
8 Super calc
9 Statsgraphics
10 Spreadsheet
11 CAD/Fault-study program
12 CAD/DSSE,POWSYS, EQUIPT

Table 5.16

The mathematics background required to use computers effectively is listed by the respondents as :

1 Complex numbers
2 Trig-functions
3 Hyperbolic function
4 Differentiation
5 O.D.E's
6 Boolean-algebra
7 Numerical methods
8 Statistics
9 Logarithmic functions
10 Vector algebra
11 Matrix algebra
12 Radix conversions
13 School mathematics
14 Fast Fourier transform
15 Financial calculations
16 Accountancy

Table 5.17

The list above does not indicate any priority. The first part of the list (1-11), coincides with the mathematics topics investigated through the questionnaire with the exception of indices, partial-differentiation and partial differential equations. The second part of the list (12 - 16) are additions to the questionnaire list except Fast Fourier Transforms which could resort under numerical methods.

5.5 <u>THE ENGINEERS DESIRE TO INVOLVE TECHNICIANS IN THE EXECUTION OF THEIR CALCULATIONS</u>

Recommendations were made by the engineers with regard to whether technicians should be involved fully, partly or not at all in the calculations performed by the engineers. The recommendations are as follows:

5.5.1. <u>Rarely used calculations:</u>

63% of engineers recommended full involvement,
14,8% of engineers recommended part involvement,
22,2% of engineers recommended no involvement.

5.5.2. <u>Occasionally used calculations:</u>

66,7% of engineers recommended full involvement,
11,1% of engineers recommended part involvement,
22,2% of engineers recommended no involvement.

5.5.3. <u>Often used calculations:</u>

54% of engineers recommended full involvement,
20,8% of engineers recommended part involvement,
25% of engineers recommended no involvement.

From the above it is seen that 76,9% of the engineering respondents want technician involvement fully or partly, in their calculations, whilst 23,1% advocates against any involvement (see pie-charts 5.20 - 5.22).

PERCENTAGE ENGINEERS RECOMMENDING ASSIS-
TANCE BY TECHNICIANS IN RARE CALCS.

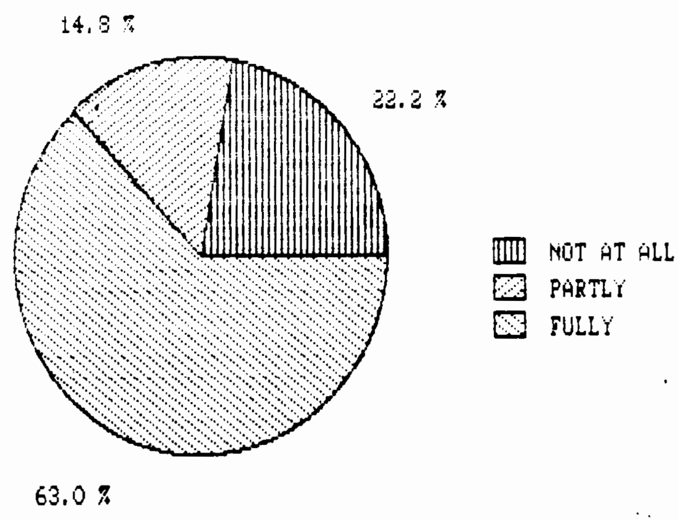


Figure 5.18

PERCENTAGE ENGINEERS RECOMMENDING ASSIS-
TANCE BY TECHNICIANS IN OCCASIONAL CALCS

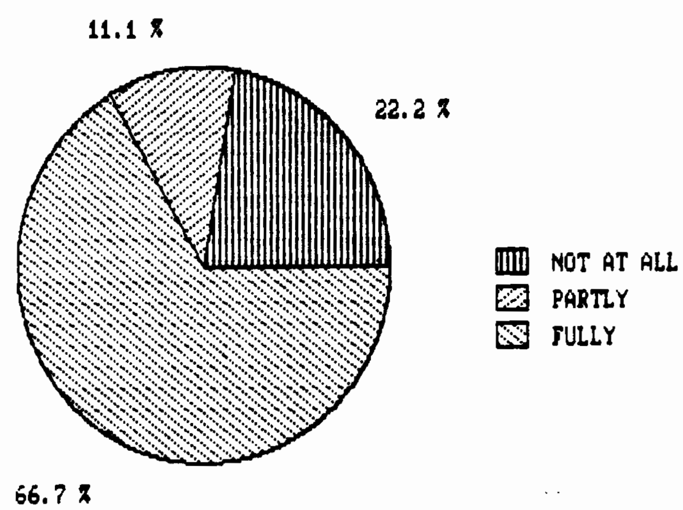


Figure 5.19

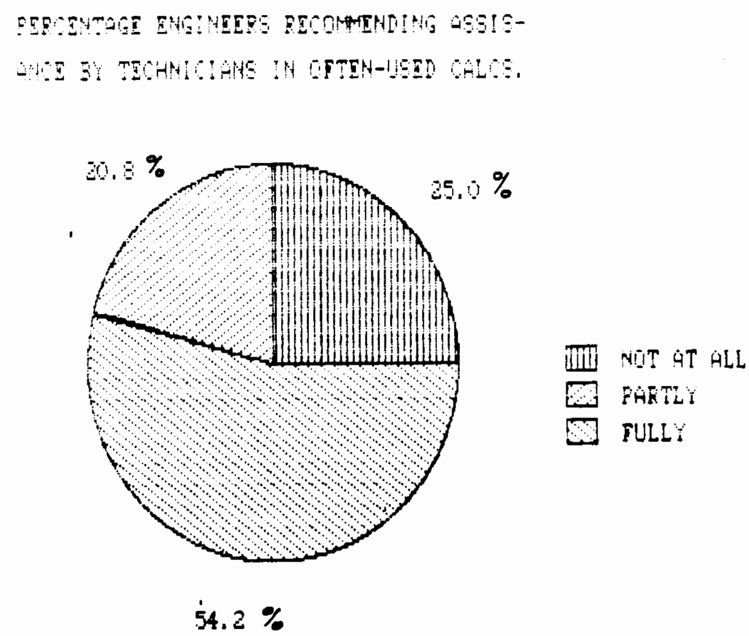


Figure 5.20

5.6 <u>TYPES OF CALCULATIONS DONE BY ENGINEERS</u>

Items 2a, 2b and 2c in the questionnaire allows for amplification of sample calculations used by engineers and technicians in the workplace. ONE HUNDRED AND FORTY-SIX sample calculations were grouped into the following relevant categories:

1 A.C. theory
2 Computer software development
3 Control systems
4 Digital systems
5 Electrical machines
6 Financial calculation
7 Illumination
8 Mechanical systems analysis
9 Network analysis
10 Power distribution
11 Power economy
12 Power electronics
13 Statistics
14 Telecommunications

Table 5.21

The percentage distribution for the whole sample, for the engineers and technicians respectively is depicted by the pie-charts below. (fig. 5.22-24).

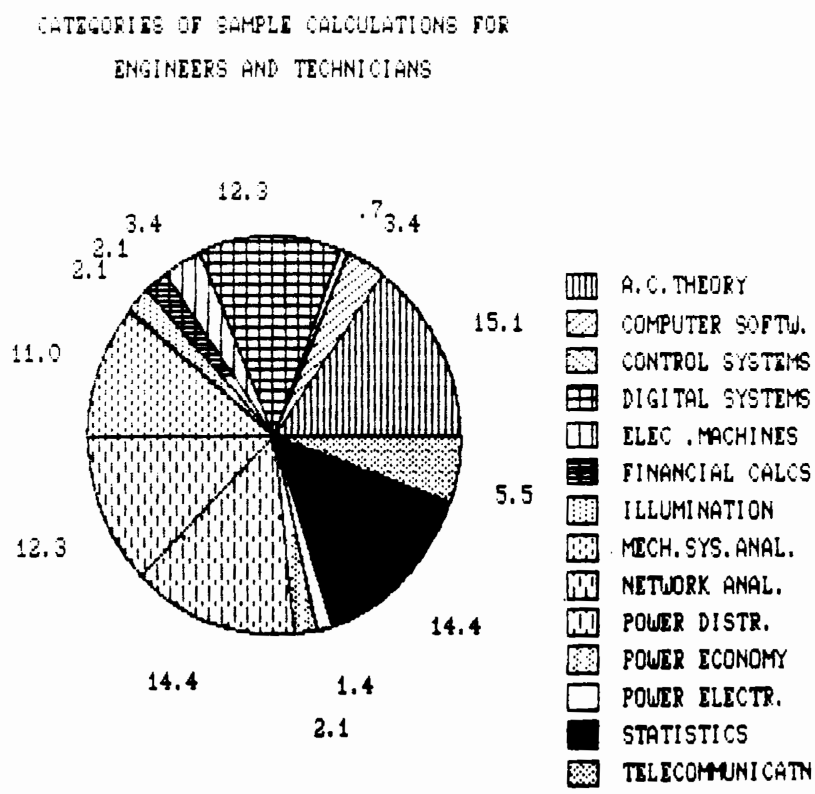


Figure 5.22

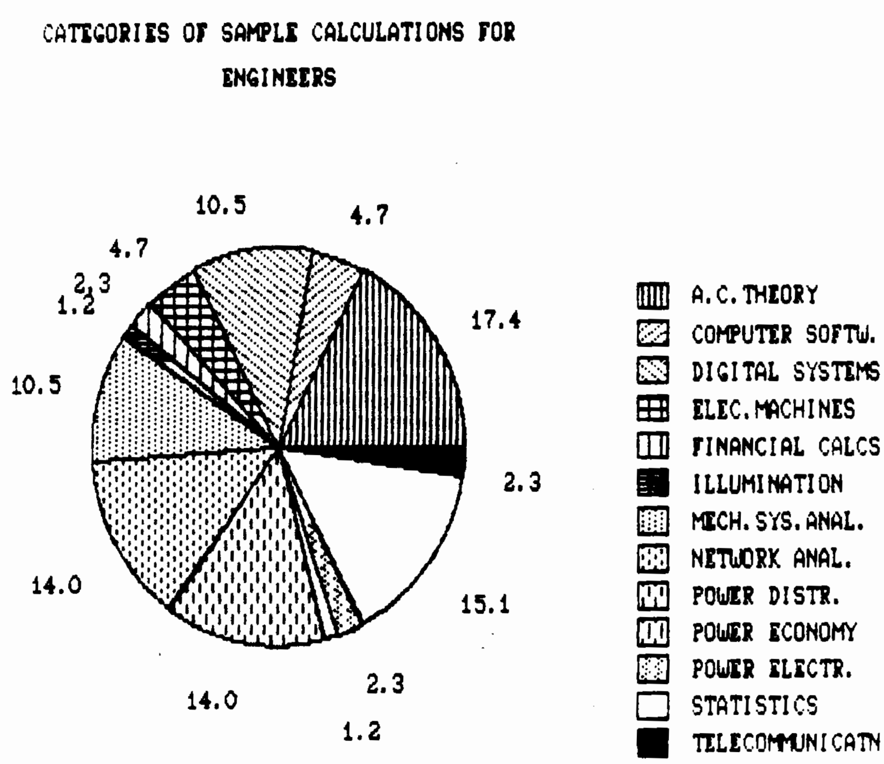


Figure 5.23

CATEGORIES OF SAMPLE CALCULATIONS FOR TECHNICIANS

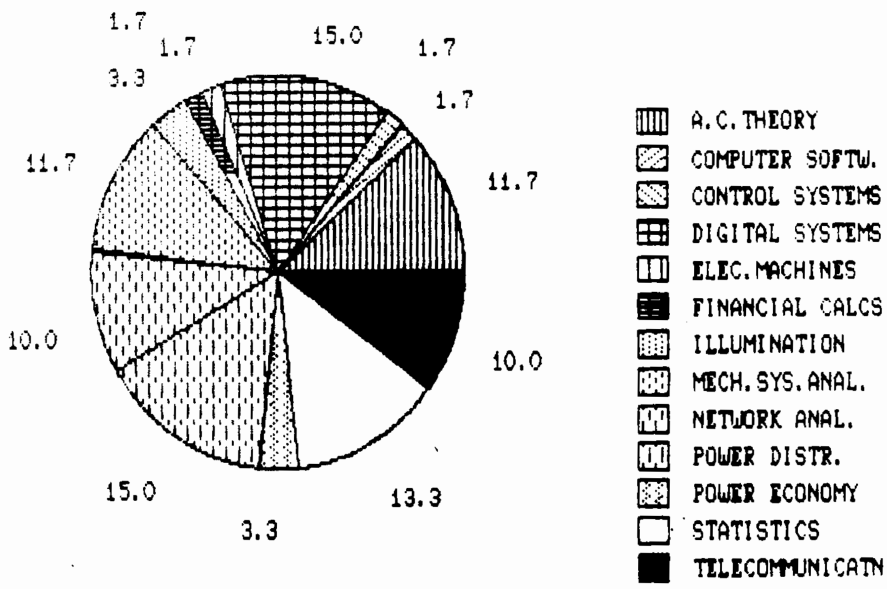


Figure 5.24

Respondents submitted 146 sample calculations in either explicit or implicit form. In other words, examples were given explicitly in mathematical form, or implicitly by verbal description. EIGHTY-SIX (59%) sample calculations were elicited from engineers while 60 (41%) sample calculations were extracted from technicians. The sample calculations cannot be regarded as fully representative of the spectrum of calculation actually used in the workplace by the respondents. Nevertheless the questionnaire makes an attempt at some measure of representativeness by reflecting rarely-used, occasionally-used and often-used calculations.

If one looks at the subject areas as listed in figures 5.22 - 5.24 it is significant that these areas of calculation activity are the same for both engineers and technicians with the exception of the category "control systems" reflected only in the sample calculations of the technicians. This category for technicians is only represented by 1,7% of the calculations for technicians analyzed. Furthermore the inter-relationship between digital-systems and control systems is so high that it is possible that engineers have included control-systems calculation under digital-systems.

One can therefore say that the calculation activity for both engineers and technicians in terms of relevant areas of calculations is the same although the frequency of calculations in these areas may differ between engineers and technicians.

These sample calculations are not used to identify mathematics topics but rather areas of mathematical activity as depicted in fig. 5.21. The rationale is that mathematics extracted from sample calculations which averages two per respondent cannot be regarded as representative of the full spectrum of mathematics used, and that the area of activity should be identified instead, in order to put us in a position to determine the mathematics used in each area or category.

5.7 OPINIONS OF ENGINEERS AND TECHNICIANS ON A MORE FUTURISTIC MATHEMATICS FOR TECHNIKONS

Those who responded to Q11 of the questionnaire (appendix 1) indicated the following:-

5.7.1 ENGINEERS

(i) Mathematics should concentrate on the development of logic and insight.
(ii) The understanding of mathematical concepts is important.
(iii) Numerical methods; the Z-transform; Boolean-algebra; should form part of the Technikon mathematics syllabus.
(iv) More time should be spent on the Laplace and Fast-Fourier transforms.
(v) The course should be computer oriented.
(vi) Finite-element analysis should be included.
(vii) Classical methods should not be neglected.

5.7.2 TECHNICIANS

(i) Boolean-algebra and statistics should be included in the syllabus.

(ii) The applied nature of mathematics should be exploited.

(iii) Mathematics should have a computer orientation.

(iv) The emphasis on calculus should be diminished.

5.7.3 SUMMARY

The analysis of the questionnaire indicates the following:-

(i) The structure of mathematics needs in employment expressed in terms of mathematics topics is the same for engineers and technicians.

(ii) The utility value of classical mathematics in the workplace has given way to numerical methods, Boolean algebra and statistics.

(iii) Topics not appearing in present mathematics syllabi are:

- (a) Boolean-algebra
- (b) Vectors
- (c) Statistics
- (d) numerical methods
- (e) fast Fourier transforms
- (f) Z-Transforms
- (g) finite element analysis

(iv) Both engineers and technicians make use of computer software packages and according to the respondents the following topics are used over and above those appearing in (iii) above:-

- (a) financial calculations
- (b) accounting

(v) The engineers advocate the involvement of technicians in all levels of calculations in the workplace.

(vi) The identification of areas of calculations in terms of electrical-engineering theory topics does not give us an explicit picture of mathematics used. Furthermore as these areas cannot be regarded as absolute in terms of mathematics required and therefore do not exclude any mathematics topic, further analysis is needed. However, the worded explanations given by some of the respondents make it impossible to determine the actual mathematics use. For example when a respondent indicates that he/she "uses Ohm's-law" or "calculates the resistance of a cable", the method of calculation (with the aid of a computer or otherwise), is unknown. The list of categories must therefore suffice as indicators of the mathematics implied by the calculation examples provided by the respondents.

(vii) The mathematics for future engineering-mathematics syllabi should concentrate on the basic concepts, development of logic and insight through relevant problem solving, leaning toward numerical methods and exposure to computers where possible.

CHAPTER 6

THE TEXT ANALYSIS

6.1 INTRODUCTION

In this chapter the mathematics used in the text references prescribed by the syllabi and lecturer's-guides (appendix 5) is extracted. The mathematics is categorised in topics. These mathematics topics were preselected from the presently-used syllabi in mathematics viz. engineering-mathematics TI01, TI02, TI03 and TI04 (see appendix 2). Forty-three topics were chosen as listed in paragraph 6.3. Each syllabus topic as amplified by the corresponding lecturer's-guides was identified in the text references prescribed by the lecturer's-guides. Mathematics topics occurring in a text chapter or syllabus topic were only scored once (see appendix 6). Where the lecturer's-guides did not include references to texts, lecturers of the department of electrical-engineering at the Peninsula Technikon were consulted in order to complete the list of text references.

The extracted data is used to show:-

(i) Frequency of mathematics topics per semester of study.
(ii) Weakness in present mathematics syllabi.
(iii) Frequency of mathematics topics per offering per semester of study.

6.2 TEXT REFERENCES ANALYZED

With the aid of available lecturer's-guides as well as consultation with lecturers in the electrical-engineering department of the Peninsula Technikon, a text-list was compiled to facilitate the text-analysis. Furthermore a random reference number was assigned to a text due to the fact that background reading and text-analysis were done simultaneously. A list of instructional-offerings against random text reference-number and text title follows. The list has been subdivided in four sections each representing a semester of study as can be seen from the offering-codes.

6.2.1 FIRST SEMESTER TEXTS (T1 LEVEL)

LIST OF INSTRUCTIONAL-OFFERINGS AND TEXTS USED AT T1 LEVEL

OFFERING CODE	RAN DOM	AUTHOR	TITLE
TDA1	34	Floyd, T.L.	Digital Fundamentals
TE11	17	Floyd, T.L.	Essentials of electronic devices
TEJ1	26	Hughes, E.	Electrical technology 6th edition
TIC1	6	Considine, D.M.	Colour and mono-TV (Vol. 3)
TIC1	64	Jones, E.B.	Instrument technology Vol.3 (1st edition)
TIJ1	74	Beer, F.A. & Johnston, E.R.	Vector mechanics for engineers Statics and dynamics

6.2.2 SECOND SEMESTER TEXTS (T2 LEVEL)

LIST OF INSTRUCTIONAL-OFFERINGS AND TEXTS USED AT T2 LEVEL

OFFERING CODE	RAN DOM	AUTHOR	TITLE
TDA2	34	Floyd, T.L.	Digital Fundamentals
TEF2	42	Say, M.G. & Taylor, E.O.	Direct-current machines (2nd edition)
TEF2	43	Say, M.G.	Alternating-current machines
TEF2	57	Golding, E.W. Widdis, F.C.	Electrical measurements & measuring instruments
TEF2	58	Langsdorf, A.S.	Principles of direct-current machines
TEI2	5	Bogart, T.F.	Electronic devices and circuits

LIST OF INSTRUCTIONAL-OFFERINGS AND

TEXTS USED AT T2 LEVEL (continued)

OFFERING CODE	RAN DOM	AUTHOR	TITLE
TEK2	18	Freeman, P.J.	Electrical transmission and distribution
TEK2	26	Hughes, E.	Electrical technology (6th edition)
TEL2	44	Shepherd, J. Morton, A.H. & Spence, L.F.	Higher electrical engineering
TIC2	36	Oberholzer, K.F	Industrial instruments for technicians - 2nd course
TSH2	76	Stephens, R.C.	Strength of materials: Theory and examples
TTB2	31	Kennedy, G.	Electronic communications systems
TTB2	33	Knight, S.A.	Electrical and electronic principles
TTB2	35	Miller, G.M.	Modern electronic communication
TTB2	41	Roddy, D. & Coolen, J.	Electronic communications
TTB2	55	Conner, F.R.	Modulation

6.2.3 THIRD SEMESTER TEXTS(T3 LEVEL)

LIST OF INSTRUCTIONAL-OFFERINGS AND

TEXTS USED AT T3 LEVEL

OFFERING CODE	RAN DOM	AUTHOR	TITLE
TIC3	3	Liptak, B.G.	Instruments engineers handbook (Vol. 2)
TDA3	75	Short, K.L.	Microprocessors and programmed logic
TEF3	26	Hughes, E.	Electrical technology (6th edition)
TEF3	43	Say, M.G.	Alternating-current machines
TEF3	44	Shepherd, J. Morton, A.H. & Spence, L.F.	Higher electrical engineering
TEG3	2	Bell, D.B.	Electronic measurements
TEG3	4	Boctor, S.A.	Electric circuit analysis:1st edition

LIST OF INSTRUCTIONAL-OFFERINGS AND

TEXTS USED AT T3 LEVEL (continued)

OFFERING CODE	RAN DOM	AUTHOR	TITLE
TEH3	11	Cooper, W.D. & Helfrick, A.D.	Electronic instrumentation measurement
TEH3	54	Spiegel, M.R.	Theory and problems of statistics
TEH3	56	Carr, J.J.	Elements of electronic instruments and measurement
TTEH3	59	Conner, F.R.	Electronic devices
TEI3	10	Bell, D.B.	Electronic devices and circuits(3rd edition)
TEK3	18	Freeman, P.J.	Electrical transmission and distribution
TEK3	26	Hughes, E.	Electrical technology(6th edition
TIA3	50	Henderson, S. & Marsden, A.M.	Lamps and lighting
TIB3	1	Considine,D.M & Ross,S.D	Handbook of applied instrumentation
TIB3	6	Considine, D.M.	Process instruments and controls handbook (2nd ed.)
TIB3	65	Haas, A.	Industrial electronics principles and practices
TIB3	66	Mansfield, P.H.	Electrical transducers for industrial measurement
TIB3	67	Kretzman, R.	Industrial electronics handbook
TIB3	68	Davis, W.L. & Weed, H.R	Industrial electronic engineering
TIB3	69	Ryder, J.D.	Engineering electronics
TIB3	70	Morris, N.M.	Advanced industrial electronics
TIB3	72	Maloney, T.J.	Industrial solid state electronics
TIC3	1	Considine,D.M.& Ross, S.D	Handbook of applied instrumentation
TIC3	37	Oberholzer, K.F	Industrial instruments for technicians:3rd course
TOG3	46	Schwarzenbach	System modelling and control
TRB3	13	Danielson, G.L. & Walker, R.S.	Radio and line transmission Vol. 2
TRB3	30	Kennedy, G. system	Electronic communications
TRB3	41	Roddy, D. & Coolen, J.	Electronic communications
TRB3	55	Conner, F.R.	Modulation
TSH3	76	Stephens, R.C.	Strength of materials:Theory and examples

LIST OF INSTRUCTIONAL-OFFERINGS AND

TEXTS USED AT T3 LEVEL (continued)

OFFERING CODE	RAN DOM	AUTHOR	TITLE
TSH3	78	Elliot, V.	Essentials of strengths of materials
TTC3	60	Hudson G.H.	Colour televison theory
TTC3	62	Wharton, W.& Howarth, D	Principles of television reception

6.2.4 FOURTH SEMESTER TEXTS (T4 LEVEL)

LIST OF INSTRUCTIONAL-OFFERINGS AND

TEXTS USED AT T4 LEVEL

OFFERING CODE	RAN DOM	AUTHOR	TITLE
TDA4	75	Short, K.L.	Microprocessors and programme logic
TDA4	77	Tugal, D. & Tugal. O.	Data transmission analysis design applications
TEF4	19	Frizgerald,A.E Kingsley, C. & Umans, S.D.	Electric machinery (4th edition)
TEF4	26	Hughes, E.	Electrical technology (6th edition
TEF4	43	Say, M.G.	Alternating current machines
TEF4	44	Shepherd, J. Morton, A.H. & Spence, L.F.	Higher electrical engineering
TEH4	11	Cooper, W.D. & Helfrick, A.D.	Electronic instrumentation and measurement
TEH4	31	Kennedy, G.	Electronic communication systems
TEH4	54	Spiegel, M.R.	Theory and problems of statistics
TEH4	56	Carr, J.J.	Elements of electronic instruments and measurement
TEK4	18	Freeman, P.J.	Electrical transmission and distribution
TEK4	50	Henderson, S.T. & Marsden, A.M.	Lamps and lighting
TEK4	52	Say, M.G.	The performance and design of alternate current machines

LIST OF INSTRUCTIONAL-OFFERINGS AND

TEXTS USED AT T4 LEVEL (continued)

OFFERING	RAN DOM	AUTHOR	TITLE
TOG4	8	Chen, C. Tsong	Analysis and synthethis of linear control systems
TOG4	23	Harrison, H.L. & Bollinger, J.G.	Introduction to automatic control
TOG4	46	Scharzenbach	System modelling & control
TSH4	76	Stephens, R.C.	Strength of materials :Theory and examples
TSH4	79	Ryder, G.H.	Strength of materials (3rd edition)
TTC4	7	Zarach, J.S. & Morris,N.M.	Television - principles and practice.
TTC4	38	Patchett, G.N.	Colour Television Measurement and measuring
TTC4	60	Hudson, G.H.	Colour television and theory
TTC4	61	Kybett, H.	The complete handbook of video tape recorders

6.3 LIST OF MATHEMATICS TOPICS USED TO CATEGORISE MATHEMATICS APPEARING IN TEXTS

This list has been compiled from the existing engineering-mathematics syllabi (see appendix 2) while provision has been made for other mathematics topics which may be encountered.

REF	TOPICS
1	Alg: Equation manipulation
2	Alg: Indices
3	Alg: Logarithms
4	Alg: Solution of quadratic equations
5	Alg: Solution of higher order equations
6	Alg: Simultaneous equations
7	Alg: Determinants
8	Alg: Matrix notation
9	Alg: of matrices
10	Alg: Graph straight line
11	Alg: Graph conic sections
12	Alg: Graph exponential function
13	Alg: Graph logarithmic functions

REF	TOPICS
14	Trig: Ratios and trigonometric identities
15	Trig: Graphs
16	Complex numbers
17	Complexors
18	Graph interpretation
19	Vectors : Basic
20	Binomial expansion
21	Gradient of a function
22	Limit of a ratio
23	Mensuration
24	Differentiation
25	Integration
26	Partial differentiation
27	Taylor or McClauren series
28	Ordinary differential equations
29	Partial differential equations
30	Laplace transform
31	Fourier transform
32	Fast Fourier transform
33	Z-transform
34	Fourier series
35	Complex integration
36	Numerical methods
37	Stats: Curve fitting
38	Stats: Frequency
39	Stats: Mean/ave.
40	Stats: Probability
41	Stats: RMS
42	Stats: Std. dev. hypothesis testing etc.
43	Boolean-algebra

6.4 MATHEMATICS TOPICS USED IN ELECTRICAL - ENGINEERING INSTRUCTIONAL - OFFERINGS

Mathematics topics utilised in instructional-offerings other than engineering-mathematics at the Peninsula Technikon per semester of study in electrical-engineering is shown in the following cross-tabulations.

CROSS-TABULATION OF MATHEMATICS BY YEAR OF STUDY

MATH REF.	YEAR-1	YEAR-2	YEAR-3	YEAR-4	Row Total
1	34 30.1	64 20.8	112 23.7	52 20.7	262 22.9
2	5 4.4	29 9.4	22 4.7	13 5.2	69 6.0
3	3 2.7	11 3.6	19 4.0	8 3.2	41 3.6
4	0 .0	1 .3	1 .2	0 .0	2 .2
5	0 .0	0 .0	2 .4	1 .4	3 .3
6	2 1.8	2 .7	2 .4	3 1.2	9 .8
7	2 1.8	0 .0	1 .2	1 .4	4 .3
9	0 .0	0 .0	0 .0	8 3.2	8 .7
10	1 .9	7 2.3	8 1.7	1 .4	17 1.5
12	1 .9	0 .0	2 .4	0 .0	3 .3
13	0 .0	1 .3	0 .0	0 .0	1 .1
14	8 7.1	42 13.7	45 9.5	20 8.0	115 10.1
15	2 1.8	17 5.5	20 4.2	9 3.6	48 4.2
16	1 .9	19 6.2	38 8.0	13 5.2	71 6.2
17	1 .9	16 5.2	33 7.0	13 5.2	63 5.5
18	20 17.7	58 18.9	98 19.7	35 13.9	206 18.0
19	8 7.1	2 .7	4 .8	3 1.2	17 1.5
20	0 .0	2 .7	1 .2	0 .0	3 .3
Column Total	113 9.9	307 26.8	473 41.3	251 21.9	1144 100.0

Table 6.1

CROSS-TABULATION OF MATHEMATICS BY YEAR OF STUDY

MATH REF.	YEAR-1	YEAR-2	YEAR-3	YEAR-4	Row Total
22	1 .9	0 .0	1 .2	1 .4	3 .3
23	2 1.8	0 .0	2 .4	3 1.2	7 .6
24	8 7.1	10 3.3	15 3.2	10 4.0	43 3.8
25	7 6.2	17 5.5	16 3.4	17 6.8	57 5.0
26	0 .0	2 .7	1 .2	2 .8	5 .4
27	0 .0	0 .0	1 .2	1 .4	2 .2
28	0 .0	1 .3	8 1.7	15 6.0	24 2.1
29	0 .0	0 .0	0 .0	1 .4	1 .1
30	0 .0	0 .0	7 1.5	5 2.0	12 1.0
31	0 .0	0 .0	1 .2	0 .0	1 .1
34	0 .0	3 1.0	4 .8	1 .4	8 .7
37	0 .0	0 .0	2 .4	2 .8	4 .3
38	0 .0	0 .0	4 .8	1 .4	5 .4
39	0 .0	0 .0	4 .8	4 1.6	8 .7
40	0 .0	0 .0	1 .2	2 .8	3 .3
41	0 .0	1 .3	0 .0	1 .4	2 .2
42	0 .0	0 .0	2 .4	3 1.2	5 .4
43	7 6.2	2 .7	1 .2	2 .8	12 1.0
Column Total	113 9.9	307 26.8	473 41.3	251 21.9	1144 100.0

Table 6.2

Tables 6.1 and 6.2 above are cross-tabulations of mathematics topics, indicated by its reference number (list in par. 6.3) in the far left-hand column, by semester of study indicated in the top row. One thousand non-zero observations have been recorded covering all the offerings in electrical-engineering offered at the Peninsula Technikon. The absence of mathematics topics 4, 8, 11, 21, 32, 33, 35 and 36 from the tables indicate that the following list of topics were not encountered in the text-analysis.

(1) Solutions to quadratic equations
(ii) Matrix notation
(iii) Graphs of conic sections
(iv) Gradient of a function
(v) Fast Fourier transforms
(vi) Z-transforms
(vii) Complex integration
(viii) Numerical methods

However, as can be seen in chapter 5, tables 5.11 and 5.17, matrix notation, Fast-Fourier-transforms and numerical methods are not necessarily excluded from the mathematics prerequisites for the successful performance of an electrical-engineering-technician.

The two numbers occurring in all the cells in tables 6.1 and 6.2, excluding the top row and the first column, indicate the frequency and percentage frequency of mathematics topics occurring in the texts. Row and column totals are indicated as well. It is significant to note that the two topics with relatively high occurrence are:-

(i) Equation manipulation 22.9% and
(ii) Graph interpretation 18.0%.

From the semester column one concludes that in order to provide necessary mathematical background to theoretical offerings per semester of study, the following topics have to be included in the syllabus. It must be stressed at this point that the list that follows for the first semester of study is necessary but not sufficient as the in- service component is not included.

FIRST SEMESTER

(i) Equation manipulation
(ii) Indices
(iii) Logarithms
(iv) Graph : Straight line
(v) Graph : Exponential function
(vi) Trigonometric graphs
(vii) Complex numbers
(viii) Complexors
(ix) Graph interpretation
(x) Differentiation
(xi) Integration
(xii) Boolean-algebra

SECOND SEMESTER

(i) Equation manipulation
(ii) Indices
(iii) Logarithms
(iv) Simultaneous equations
(v) Graph : Straight line
(vi) Graph : logarithmic function
(vii) Trigonometric graphs
(viii) Trigonometric equations
(ix) Complex numbers
(x) Complexors
(xi) Graph interpretation
(xii) Vectors : basic
(xiii) Binomial expansion
(xiv) Differentiation
(xv) Integration
(xvi) Partial differentiation
(xvii) Ordinary differential equations
(xviii) Fourier series
(xix) Stats : R.M.S.
(xx) Boolean-algebra

THIRD SEMESTER

(i) Equation manipulation
(ii) Indices
(iii) Logarithms
(iv) Solution of 3rd degree and higher equations
(v) Simultaneous equations
(vi) Determinants
(vii) Graph : Straight line
(viii) Graph : exponential function
(ix) Trigonometric ratios and identities
(x) Trigonometric graphs
(xi) Complex numbers
(xii) Complexors
(xiii) Graph interpretation
(xiv) Vectors basic
(xv) Binomial expansion
(xvi) Limit of a ratio
(xvii) Mensuration
(xviii) Differentiation
(xix) Integration
(xx) Partial differentiation
(xxi) Taylor and McLauren series
(xxii) Ordinary differential equations
(xxiii) Laplace transforms
(xxiv) Fourier transforms
(xxv) Fourier series
(xxvi) Stats : curve fitting
(xxvii) Stats : frequency distribution
(xxviii) Stats : mean/ave.
(xxix) Stats : Probability
(xxx) Stats : standard deviation and hypothesis testing

FOURTH SEMESTER

(i) Equation manipulation
(ii) Indices
(iii) Logarithms
(iv) Solution of 3rd degree and higher equation
(v) Simultaneous equations

(vi) Determinants
(vii) Matrix algebra
(viii) Graph : straight line
(ix) Trigonometric ratios and identities
(x) Trigonometric graphs
(xi) Complex numbers
(xii) Complexors
(xiii) Graph interpretation
(xiv) Vectors : basic
(xv) Limit of a ratio
(xvi) Mensuration
(xvii) Differentiation
(xviii) Integration
(xix) Partial differentiation
(xx) Taylor and McLauren series
(xxi) Ordinary differential equations
(xxii) Partial differential equations
(xxiii) Laplace transforms
(xxiv) Fourier series
(xxv) Stats : curve fitting
(xxvi) Stats : frequency distribution
(xxvii) Stats : mean/ave.
(xxviii) Stats : probability
(xxix) Stats : R.M.S.
(xxx) Stats : standard deviation and hypothesis testing

6.5 WEAKNESSES IN PRESENT SYLLABI I.T.O. TEXT ANALYSIS

In terms of the mathematical requirements as exposed by the text analysis, the following weaknesses are apparent when one examines the present syllabi:-

(i) As equation manipulation is a major component of mathematics requirements in each semester of study, more emphasis should be placed on this aspect.
(ii) The interpretation of graphs should receive more attention.

(iii) Boolean-algebra appears as both a first and second semester prerequisite and could form part of the engineering-mathematics syllabus.

(iv) The basic concept of vector addition should be included in the syllabus of engineering-mathematics as from the second semester of theoretical study.

(v) Statistics should be included as from the semester onwards.

6.6 IMPLICATIONS FOR THE LECTURER

Knowing which mathematics topics are needed in the engineering-mathematics syllabus in order to satisfy both theory and practice is by no means sufficient to put the mathematics lecturer in a position which satisfies the basic concept of co-operative education. This fundamental premise is one of co-operation. In the case of the mathematics lecturer it is a case of co-operation between industry and serviced-offerings (i.e. instructional-offerings other than engineering-mathematics requiring mathematics as a supporting science for it to be understood properly) with the aim to devise the specifications for the mathematics syllabi. The motivation for such premise is to enhance and emphasise the relevance of mathematics as a vocational tool. It is therefore important for the mathematics lecturer not only to know a list of topics to be included in the mathematics syllabus but it is essentially important to know:-

1. In which offerings mathematics is used and to what extent.

2. Whether there are any idiosyncratic approaches in the application of basic mathematical concepts in other offerings and in practice.

3. Where examples of the real application of mathematics can be found pertaining to the theoretical/in- service training of the aspirant technician.

For many mathematics lecturers the questions above could be daunting and even a dilemma. In order to assist in this perplexity:-

1. An indication of the use of mathematics in serviced-offerings is given in the first set of frequency tables following.

2. The location of mathematics topics used in text references to serviced-offerings is indicated per semester of study in appendix 6.

6.7 USE OF MATHEMATICS PER INSTRUCTIONAL-OFFERING SUPPORTED/SERVICED BY MATHEMATICS.

Tables 6.3-6.6 constitutes a set of cross-tabulations of mathematics topic by instructional-offering indicating the frequency and percentage frequency of mathematics topics per instructional offering. All instructional-offerings are grouped together per semester of study. The instructional-offerings are indicated in code-form in the top row of each table whereas the mathematics topic-references as listed in paragraph 6.3 appears in the extreme left column. The far right-hand column indicates the total frequency and percentage frequency per mathematics topic per semester of study which matches tables 6.1 and 6.2 as a check. In the double-numbered cells the top number indicates the frequency of occurrence and the second number the percentage frequency of occurrence of the mathematics topic.

6.8 REMARKS

It should be noted that if one compares the list of instructional-offerings as depicted in paragraph 2.7 (d) with the offering-codes appearing in tables 6.3 - 6.6 then it will be noticed that TIF3 (Engineering Management T3 - optional at T3), TER4 (Electronic Design T4), TIC4 (Industrial Instrument T4) and TRB4 (Radio Engineering T4), are absent. The reason being that these offerings were not offered over the last four semesters at the Peninsula Technikon and consequently were ignored in the text analysis. From these tables one gleans that the high occurrence of Equation Manipulation (1) and Interpretation of Graphs (18) is fairly evenly distributed among the offerings supported by mathematics. One also notices that calculus, in specific differentiation (24), occurs only in TEI.1 (Electronics T1); TEJ.1 (Electrical Engineering T1) and TIJ.1 (Engineering Mechanics T1).

In a similar way tables 6.3 to 6.6 can be scrutinised by the mathematics lecturer to determine in which offerings a specific topic occur. With the help of the lists of texts in 6.2.1 to 6.2.5 appropriate examples of applications useful in the teaching of mathematics can be located. Appendix 6 is very helpful in this respect.

CROSS-TABULATION OF MATHEMATICS TOPICS BY FIRST-SEMESTER INSTRUCTIONAL-OFFERINGS

	TDA1	TEI1	TEJ1	TIC1	TIJ1	Row Total
1	1 10.0	7 41.2	9 34.6	9 64.3	8 17.4	34 30.1
2	1 10.0	0 .0	1 3.8	1 7.1	2 4.3	5 4.4
3	0 .0	0 .0	1 3.8	0 .0	2 4.3	3 2.7
6	0 .0	0 .0	0 .0	0 .0	2 4.3	2 1.8
7	0 .0	0 .0	0 .0	0 .0	2 4.3	2 1.8
10	0 .0	1 5.9	0 .0	0 .0	0 .0	1 .9
12	0 .0	0 .0	1 3.8	0 .0	0 .0	1 .9
14	0 .0	0 .0	0 .0	0 .0	8 17.4	8 7.1
15	0 .0	0 .0	1 3.8	0 .0	1 2.2	2 1.8
16	0 .0	1 5.9	0 .0	0 .0	0 .9	1 .9
17	0 .0	0 .0	1 3.8	0 .0	0 .0	1 .9
18	1 10.0	7 41.2	6 23.1	4 28.6	2 4.3	20 17.7
19	0 .0	0 .0	0 .0	0 .0	8 17.4	8 7.1
22	0 .0	0 .0	0 .0	0 .0	1 2.2	1 .9
23	0 .0	0 .0	0 .0	0 .0	2 4.3	2 1.8
24	0 .0	1 5.9	4 15.4	0 .0	3 6.5	8 7.1
25	0 .0	0 .0	2 7.7	0 .0	5 10.9	7 6.2
43	7 70.0	0 .0	0 .0	0 .0	0 .0	7 6.2
Column Total	10 8.8	17 15.0	26 23.0	14 12.4	46 40.7	113 100.0

Table 6.3

CROSS-TABULATION OF MATHEMATICS TOPICS BY SECOND SEMESTER INSTRUCTIONAL OFFERINGS

	TBA2	TEP2	TRI2	TEE2	TEL2	TIC2	TSM2	TTB2	Row Total
1	4	14	5	7	6	8	4	16	64
	44.4	21.2	22.7	23.3	25.0	25.8	21.1	15.1	20.8
2	1	3	2	0	0	7	3	13	29
	11.1	4.5	9.1	.0	.0	22.6	15.8	12.3	9.4
3	0	1	1	0	0	0	1	8	11
	.0	1.5	4.5	.0	.0	.0	5.3	7.5	3.6
4	0	0	0	0	0	0	1	0	1
	.0	.0	.0	.0	.0	.0	5.3	.0	.3
6	0	1	0	0	0	1	0	0	2
	.0	1.5	.0	.0	.0	3.2	.0	.0	.7
10	0	3	1	0	0	2	0	1	7
	.0	4.5	4.5	.0	.0	6.5	.0	.9	2.3
13	0	0	0	0	0	1	0	0	1
	.0	.0	.0	.0	.0	3.2	.0	.0	.3
14	0	7	3	6	5	1	1	19	42
	.0	10.6	13.6	20.0	20.8	3.2	5.3	17.9	13.7
15	0	1	0	0	0	0	0	16	17
	.0	1.5	.0	.0	.0	.0	.0	15.1	5.5
16	0	4	2	2	1	0	0	10	19
	.0	6.1	9.1	6.7	4.2	.0	.0	9.4	6.2
17	0	3	0	4	2	0	1	6	16
	.0	4.5	.0	13.3	8.3	.0	5.3	5.7	5.2
18	2	25	6	7	6	7	1	4	58
	22.2	37.9	27.3	23.3	25.0	22.6	5.3	3.8	18.9
19	0	0	0	0	0	0	0	2	2
	.0	.0	.0	.0	.0	.0	.0	1.9	.7
20	0	0	0	0	0	0	0	2	2
	.0	.0	.0	.0	.0	.0	.0	1.9	.7
24	0	3	1	0	2	1	2	1	10
	.0	4.5	4.5	.0	8.3	3.2	10.5	.9	3.3
25	0	0	1	3	1	3	4	5	17
	.0	.0	4.5	10.0	4.2	9.7	21.1	4.7	5.5
26	0	1	0	0	0	0	1	0	2
	.0	1.5	.0	.0	.0	.0	5.3	.0	.7
28	0	0	0	1	0	0	0	0	1
	.0	.0	.0	3.3	.0	.0	.0	.0	.3
34	0	0	0	0	0	0	0	3	3
	.0	.0	.0	.0	.0	.0	.0	2.8	1.0
41	0	0	0	0	1	0	0	0	1
	.0	.0	.0	.0	4.2	.0	.0	.0	.3
43	2	0	0	0	0	0	0	0	2
	22.2	.0	.0	.0	.0	.0	.0	.0	.7
Column Total	9	66	22	30	24	31	19	106	307
	2.9	21.5	7.2	9.8	7.8	10.1	6.2	34.5	100.0

Table 6.4

CROSS-TABULATION OF MATHEMATICS TOPICS BY 3RD SEMESTER INSTRUCTIONAL OFFERINGS

Table 6.5a

	TDA3	TEF3	TEG3	TEH3	TEI3	TEK3	TIA3	TIB3	TIC3	TOG3	TRB3	TSH3	TTC3	Row Total
1	1	36	5	10	7	8	7	5	1	7	12	7	6	112
	.9	32.1	4.5	8.9	6.3	7.1	6.3	4.5	.9	6.3	10.7	6.3	5.4	23.7
2	1	0	0	4	0	1	0	3	2	0	5	6	0	22
	4.5	.0	.0	18.2	.0	4.5	.0	13.6	9.1	.0	22.7	27.3	.0	4.7
3	1	0	0	3	1	3	0	0	1	3	5	1	1	19
	5.3	.0	.0	15.8	5.3	15.8	.0	.0	5.3	15.8	26.3	5.3	5.3	4.0
4	0	0	0	0	0	0	0	0	0	0	0	1	0	1
	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	100.0	.0	.2
5	0	0	0	0	0	0	0	0	0	2	0	0	0	2
	.0	.0	.0	.0	.0	.0	.0	.0	.0	100.0	.0	.0	.0	.4
6	0	0	0	1	0	0	0	0	0	0	0	1	0	2
	.0	.0	.0	50.0	.0	.0	.0	.0	.0	.0	.0	50.0	.0	.4
7	0	0	0	0	0	0	0	0	0	1	0	0	0	1
	.0	.0	.0	.0	.0	.0	.0	.0	.0	100.0	.0	.0	.0	.2
10	0	2	0	0	0	0	0	3	0	0	3	0	0	8
	.0	25.0	.0	.0	.0	.0	.0	37.5	.0	.0	37.5	.0	.0	1.7
12	0	0	0	0	0	0	0	0	0	2	0	0	0	2
	.0	.0	.0	.0	.0	.0	.0	.0	.0	100.0	.0	.0	.0	.4
14	0	12	1	1	0	5	6	1	0	3	10	4	2	45
	.0	26.7	2.2	2.2	.0	11.1	13.3	2.2	.0	6.7	22.2	8.9	4.4	9.5
15	0	0	0	3	0	0	0	5	1	1	10	0	0	20
	.0	.0	.0	15.0	.0	.0	.0	25.0	5.0	5.0	50.0	.0	.0	4.2
16	0	18	2	2	1	3	0	1	0	6	5	0	0	38
	.0	47.4	5.3	5.3	2.6	7.9	.0	2.6	.0	15.8	13.2	.0	.0	8.0
17	0	22	1	0	0	2	0	0	0	5	2	0	1	33
	.0	66.7	3.0	.0	.0	6.1	.0	.0	.0	15.2	6.1	.0	3.0	7.0
18	1	12	2	11	5	4	10	17	2	18	5	1	5	93
	1.1	12.9	2.2	11.8	5.4	4.3	10.8	18.3	2.2	19.4	5.4	1.1	5.4	19.7
19	0	2	0	0	0	0	0	1	0	0	1	0	0	4
	.0	50.0	.0	.0	.0	.0	.0	25.0	.0	.0	25.0	.0	.0	.8
20	0	0	0	0	0	0	0	1	0	0	0	0	0	1
	.0	.0	.0	.0	.0	.0	.0	100.0	.0	.0	.0	.0	.0	.2

Table 6.5b

CROSS-TABULATION OF MATHEMATICS TOPICS BY 3RD SEMESTER INSTRUCTIONAL OFFERINGS (cont.)

	TDA3	TEF3	TEG3	TEH3	TEI3	TEK3	TIA3	TIB3	TIC3	TOG3	TRB3	TSH3	TTC3	Row Total
22	0	0	0	0	0	0	0	0	0	1	0	0	0	1
	.0	.0	.0	.0	.0	.0	.0	.0	.0	100.0	.0	.0	.0	.2
23	0	2	0	0	0	0	0	0	0	0	0	0	0	2
	.0	100.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.4
24	0	6	0	0	0	1	2	2	0	1	0	3	0	15
	.0	40.0	.0	.0	.0	6.7	13.3	13.3	.0	6.7	.0	20.0	.0	3.2
25	1	0	0	1	0	4	4	0	0	2	2	2	0	16
	6.3	.0	.0	6.3	.0	25.0	25.0	.0	.0	12.5	12.5	12.5	.0	3.4
26	0	0	0	1	0	0	0	0	0	0	0	0	0	1
	.0	.0	.0	100.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.2
27	0	0	0	1	0	0	0	0	0	0	0	0	0	1
	.0	.0	.0	100.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.2
28	0	0	0	0	0	2	0	0	0	5	0	1	0	8
	.0	.0	.0	.0	.0	25.0	.0	.0	.0	62.5	.0	12.5	.0	1.7
30	0	0	0	0	0	0	0	0	0	7	0	0	0	7
	.0	.0	.0	.0	.0	.0	.0	.0	.0	100.0	.0	.0	.0	1.5
31	0	0	0	0	0	0	0	1	0	0	0	0	0	1
	.0	.0	.0	.0	.0	.0	.0	100.0	.0	.0	.0	.0	.0	.2
34	0	2	0	0	0	0	0	1	0	0	1	0	0	4
	.0	50.0	.0	.0	.0	.0	.0	25.0	.0	.0	25.0	.0	.0	.8
37	0	0	0	2	0	0	0	0	0	0	0	0	0	2
	.0	.0	.0	100.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.4
38	0	0	0	3	0	0	0	0	1	0	0	0	0	4
	.0	.0	.0	75.0	.0	.0	.0	.0	25.0	.0	.0	.0	.0	.8
39	0	0	0	4	0	0	0	0	0	0	0	0	0	4
	.0	.0	.0	100.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.8
40	0	0	0	1	0	0	0	0	0	0	0	0	0	1
	.0	.0	.0	100.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.2
42	0	0	0	1	0	0	0	0	1	0	0	0	0	2
	.0	.0	.0	50.0	.0	.0	.0	.0	50.0	.0	.0	.0	.0	.4
43	1	0	0	0	0	0	0	0	0	0	0	0	0	1
	100.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.2
Column Total	6	114	11	49	14	33	29	41	9	64	61	27	15	473
	1.3	24.1	2.3	10.4	3.0	7.0	6.1	8.7	1.9	13.5	12.9	5.7	3.2	100.0

Table 6.5b

CROSS-TABULATION OF MATHEMATICS TOPICS BY 3RD SEMESTER INSTRUCTIONAL OFFERINGS (cont.)

	TDA3	TEF3	TEG3	TEH3	TEI3	TEK3	TIA3	TIB3	TIC3	TOG3	TRB3	TSH3	TTC3	Row Total
22	0	0	0	0	0	0	0	0	0	1	0	0	0	1
	.0	.0	.0	.0	.0	.0	.0	.0	.0	100	.0	.0	.0	.2
23	0	2	0	0	0	0	0	0	0	0	0	0	0	2
	.0	100.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.4
24	0	6	0	0	0	1	2	2	0	1	0	3	0	15
	.0	40.0	.0	.0	.0	6.7	13.3	13.3	.0	6.7	.0	20.0	.0	3.2
25	1	0	0	1	0	4	4	0	0	2	2	2	0	16
	6.3	.0	.0	6.3	.0	25.0	25.0	.0	.0	12.5	12.5	12.5	.0	3.4
26	0	0	0	1	0	0	0	0	0	0	0	0	0	1
	.0	.0	.0	100.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.2
27	0	0	0	1	0	0	0	0	0	0	0	0	0	1
	.0	.0	.0	100.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.2
28	0	0	0	0	0	2	0	0	0	5	0	1	0	8
	.0	.0	.0	.0	.0	25.0	.0	.0	.0	62.5	.0	12.5	.0	1.7
30	0	0	0	0	0	0	0	0	0	7	0	0	0	7
	.0	.0	.0	.0	.0	.0	.0	.0	.0	100.0	.0	.0	.0	1.5
31	0	0	0	0	0	0	0	1	0	0	0	0	0	1
	.0	.0	.0	.0	.0	.0	.0	100.0	.0	.0	.0	.0	.0	.2
34	0	2	0	0	0	0	0	1	0	0	1	0	0	4
	.0	50.0	.0	.0	.0	.0	.0	25.0	.0	.0	25.0	.0	.0	.8
37	0	0	0	2	0	0	0	0	0	0	0	0	0	2
	.0	.0	.0	100.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.4
38	0	0	0	3	0	0	0	0	1	0	0	0	0	4
	.0	.0	.0	75.0	.0	.0	.0	.0	25.0	.0	.0	.0	.0	.8
39	0	0	0	4	0	0	0	0	0	0	0	0	0	4
	.0	.0	.0	100.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.8
40	0	0	0	1	0	0	0	0	0	0	0	0	0	1
	.0	.0	.0	100.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.2
42	0	0	0	1	0	0	0	0	1	0	0	0	0	2
	.0	.0	.0	50.0	.0	.0	.0	.0	50.0	.0	.0	.0	.0	.4
43	1	0	0	0	0	0	0	0	0	0	0	0	0	1
	100.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.2
Column	6	114	11	49	14	33	29	41	9	64	61	27	15	473
Total	1.3	24.1	2.3	10.4	3.0	7.0	6.1	8.7	1.9	13.5	12.9	5.7	3.2	100.0

CHAPTER 7

COMPARISONS, SUMMARY OF FINDING AND RECOMMENDATIONS

7.1 INTRODUCTION

In this chapter a review of the study will be followed by some comparisons. Firstly comparisons will be drawn between findings of this research and those of relevant research as mentioned in chapter 3. Secondly the findings of this research, with regard to content for the engineering-mathematics syllabus, will be compared with existing mathematics syllabi (appendix 2) as well as the mathematics syllabi proposed by the work-group (appendix 3). While the first comparisons will be seeking for similarities with, and differences between the findings of this research and other research-based authority, the second comparison will focus on the acceptance or rejection of present as well as the proposed engineering-mathematics syllabi.

Following the comparisons will be a summary of findings other than those featuring in the comparisons above.

7.2 REVIEW

The constant modernization of industry impels the educational support services to adapt in terms of items of knowledge provided as well as educational strategies. This nexus between industry and education has a particular focus on technikons in the Republic of South Africa. The bond is cemented through legislation laying down the mandate for the technikon with respect to its function as an educational support institution. This mandate implores the technikon to formulate a basic philosophy in support of vocational training. This training is conducted at a tertiary level in support of higher level manpower. To strengthen its role the technikon adopts the aims and philosophy of co-operative education necessitating meaningful contact with employing institutions with the aim of preparing students for a specific vocation.

The research draws attention to the need for change of the mathematics curriculum and undertakes to effect the change if necessary, based on the Kruger curriculum development model as adapted for technikons-mathematics by Van Rooy. The basis for the strategy employed is drawn from relevant research as amplified in chapter 3. The strategy of this research involves firstly a questionnaire the aim of which is to extract the present and future mathematics requirements from the employing institutions for electrical-engineering technicians. Secondly a text analysis is employed to extract all the mathematics used in the references to the electrical-engineering instructional-programmes with the exception of engineering-mathematics. Finally the strategy involves a comparison of engineering-mathematics syllabi proposed by a work-group representative of all lecturers at all technikons in the Republic. The combined outcomes of the research is formulated in this chapter.

7.3 COMPARISONS

In comparing the findings of the studies in chapter 3 with those of this survey there seems to be general agreement on the need for Statistics in electrical-engineering instructional-programmes at tertiary level. The Nordic study (Hastad 1968) finds that the demand for mathematics topics by technician-training is the same in theory and employment. In this study, however, it is found that the range of topics demanded by theory may be overlapping to some extent with the workplace demand. Topics such as Boolean-algebra, Statistics, numerical-analysis and financial calculations are demanded by employment and not by electrical- engineering theory. The Israeli study (Berenson and Robinson 1983) shares this finding. This research also agrees with the Israeli study that the utility value of classical mathematics, although still important as background, is diminishing; that computers are used increasingly in the workplace; and that the theoretical background to technician training prescribed by existing mathematics syllabi is inadequate.

Furthermore the indication by this study that there is no difference in the structure of mathematics demanded by engineers and technicians respectively agrees with the findings of Strauss and Diab (1988) that academic qualification does not play a role.

In comparing the findings of the questionnaire and text analysis it is evident that the in-service and theory requirements for technician-mathematics, expressed in terms of topics, are not exactly the same. There is a measure of overlapping between the two sets of requirements. Topics common to both the electrical-engineering industry requirements and the theory requirements are listed in table 7.1.

1. Logarithms
2. Trigonometric functions
3. Statistics
4. Boolean-algebra
5. Vectors
6. Indices
7. Complex numbers
8. Differentiation
9. Ordinary differential equations
10 Partial differentiation

Table 7.1

Topics exclusively dictated by the electrical-engineering industry, according to this research, are listed in table 7.2.

1. Numerical methods
2. Hyperbolic functions
3. Matrices
4. Partial differential equations
5. Financial calculations and accounting
6. Fast-Fourier-transforms
7. Z-transforms
8. Finite-element analysis
9. computer applications

Table 7.2

Furthermore the comparison indicates that the mathematics topics required exclusively by theory in the electrical-engineering instructional-programmes are as listed in table 7.3.

1. Equation manipulation
2. Graphs : straight line; exponential; trigonometric and logarithmic
3. Graphical interpretations as used in experiments
4. Trigonometric identities
5. Mensuration
6. Simultaneous algebraic equations
7. Determinants
8. Binomial expansion
9. Limits of a ratio
10. Series: Taylor; McLauren; Fourier
11. Solution of algebraic equations of the 3rd degree and higher.
12. Transforms : Laplace; Fourier

Table 7.3

A revision of the present engineering-mathematics syllabi needs to take cognisance of tables 7.1, 7.2 and 7.3 combined. Comparing the above tables with the present engineering-mathematics syllabi (appendix 2) it is evident that the following topics are not catered for by the present engineering-mathematics syllabi.

1. Graphs of logarithmic and exponential functions
2. Statistics
3. Boolean-algebra
4. Vector theory
5. Numerical methods
6. Matrix algebra
7. Solution of algebraic equations of the third degree and higher
8. Financial calculations and accountancy
9. Fast-Fourier transforms
10. Z-transforms
11. Finite-element analysis
12. Computer applications

Also the present engineering-mathematics syllabi contains topics not required by the electrical-engineering students in terms of the findings of this research. These topics are :-

1. Co-ordinate geometry
2. complex variables

By this comparison between the present syllabi appearing in appendix.2 with the findings of this study it is clear that the present engineering-mathematics syllabi is in need of revision.

From the raw data of the text analysis in appendix 6 it can be seen that Boolean-algebra only occurs in the instructional-offering Digital-systems (code TDA). The present practice at technikons is that Boolean-algebra is taught within the instructional-offering Digital-systems. Furthermore financial calculations and accountancy appears more at home in an instructional-offering such as engineering-management (see appendix 5).

Using the above reasons as a basis for an argument to include Boolean-algebra, financial-calculations and accountancy in instructional-offerings other than engineering-mathematics,the findings based on the questionnaire and text analysis is compared with the proposals of the work-group set out in appendix 3. Firstly a topic comparison will be made using the outcomes depicted in tables 7.1 - 7.4 and the mathematics topics included in the proposed syllabi in appendix 3. Secondly the topic requirements in paragraph 6.4 will be compared with the proposed syllabi per semester of study. A topic by topic comparison reveals that Boolean- algebra, financial-calculations and accountancy are not included as topics in the concept syllabi. If one retains the previous argument that these topic can be included in other instructional-offerings, then we can ignore this shortcoming in the proposed syllabi. The solution of 3rd degree and higher algebraic equations is not explicitly stated in the proposed syllabi but will inevitably be dealt with in the Newton-Raphson method appearing in the proposed syllabus for engineering-mathematics TI01 paragraph 3.1.5 (appendix 3). The interpretation of graphical representations based on experimental results is not dealt with in the proposed syllabi which can be regarded as a weakness. Indices is not listed as a topic in appendix 3 but it should be noted that this topic is dealt with in the matric syllabus. Matric mathematics is a prerequisite for the electrical-engineering instructional-programme. The only other topics suggested by the proposed syllabi which do not match the outcomes of the text analysis are partial fractions, finite- element-analysis, Z-transforms and numerical-methods. However, partial-fractions is prerequisite knowledge for integration-techniques while numerical-methods is a required mathematics topic in accordance with the questionnaire analysis. Also if one compares the proposed syllabi with the future trends in mathematics envisaged by engineers and technicians as expressed in 5.7 then it is evident that the Z-transform and finite-element-analysis is called for. These two topics together with statistics are included in the proposed syllabus of engineering-mathematics TI04 as options (appendix 3).

In comparing the proposed syllabi on a semester of study basis with the results of the text analysis in paragraph 6.4 there seems to be two weaknesses. One weakness is the fact that the Fourier-series is required in the second semester but is only included in the proposed syllabus of the third semester (Engineering-mathematics TI03). The second weakness is that Fourier-transforms, according to the text analysis, is required in the third semester while the concept syllabus engineering-mathematics TI04, only deals with the topic in the fourth semester. All other topics are proposed well ahead of or during the semester they are required. The fact that a topic is presented well ahead of its required time may be problematic in terms of retention of learning material as far as the student is concerned. This situation is inevitable if one is careful not to overload a syllabus which has to be completed in six months. However, the fact that the need for a topic is known in terms of the semester of study makes it imperative that many of the first and second-semester proposed topics be revised in the second and third semester as required by paragraph 6.4.

Summarising, it can be said that the proposed syllabi largely satisfy the outcomes of syllabus requirements obtained from the questionnaire and text analysis. However, there appear to be three weaknesses which can be rectified easily. These weaknesses are:-

1. The absence of the graphical interpretation of experimental results;
2. The Fourier series is presented in the third instead of the second semester;
3. The Fourier-transform is dealt with in the fourth semester instead of the third semester.

7.4 SUMMARY OF FINDINGS

7.4.1. The questionnaire

From the questionnaire the following conclusions were drawn:-

(a) On average the mathematics used by engineers does not differ from that used by technicians. This supports the idea that job description within the same discipline does not make a significant difference to the mathematics used. This is of course not true for a technician who has a purely maintenance and/or installation function.

(b) A high percentage (54%+) of engineers in the workplace recommend that the technician be more involved in all of the calculations presently performed by engineers mainly. 76.9% of the engineers want technician involvement partly or fully.

(c) The areas of calculations in which technicians should assist engineers are:-

A.C. theory
Computer software development
Control systems
Digital systems
Electrical machines
Financial calculations

Illumination
Mechanical systems analysis
Network analysis
Power distribution
Power economy
Power electronics
Statistics
Telecommunication

However, the survey indicates that the categories of sample calculations above is equally applicable to the technician sample calculations excepting that the frequency of occurrence is much higher for engineers. The low frequency indicates that only certain technicians are involved in the above categories of calculations.

Alternatively it can be argued that because of the low frequency for technicians, the engineers at present have little confidence in the mathematical capabilities of a majority of technicians.

(d) Classical mathematics still enjoys a high priority as background with engineers and technicians whilst its utility value has given way to numerical methods, Boolean algebra and statistics.

(d) The increasing use of computer software programmes in the workplace requires a background knowledge of the following topics over and above those appearing in present syllabi.

(i) Radix conversions
(ii) Fast Fourier transforms
(iii) Financial calculations

(f) Future trends in mathematics taught at technikons are speculated on by the respondents. This speculation is based on present day desires in the workplace which are not fully satisfied by the present syllabus of engineering-mathematics. The respondents want to see a mathematics syllabus with the following characteristics:-

(i) More emphasis on the application of mathematics
(ii) Statistics should be introduced
(iii) Boolean-algebra should be added
(iv) Where expedient, the use of computer software programmes in mathematics should be advocated
(v) Computer-oriented mathematics should form part of the syllabus with analytical methods occupying less prominence
(vi) Basic mathematics concept understanding should receive prominence
(vii) Real problem-solving techniques should be fostered
(viii) More time should be allocated to Laplace and Fast-Fourier Transforms (computer oriented where possible)
(ix) Numerical-methods with aid of the personal computer should be taught
(x) Finite-element-analysis should be introduced (computer oriented where possible)
(xi) Emphasis on numerical methods should not neglect calculus
(xii) Mathematics should be applicable to real life problems

7.4.2 The text analysis

The mathematics required by the offerings serviced by mathematics is extracted in terms of distinct mathematics topics from the prescribed texts as detailed in chapter 6. Conclusions through this analysis are:-

(a) Equation manipulation and graphical interpretations receive high priority in terms of frequency of occurrence in the text analysis.
(b) The statistics demanded by the text analysis include:-

 (i) Curve fitting
 (ii) Frequency distribution

economic and political factors influencing the student's ability to cope with mathematics at the technikon. By virtue of the influence of co-operative education on the situation, technikon students are different from school and university students in the sense that they are (or should be) employed while studying. Has this situation an influence on the learning process? Once questions such as these can be answered to a reasonable extent then learning strategies, based on sound learning theory, could be suggested and tested for viability.

7. Researchers in mathematics education must bear in mind that the main problem in formulating aims for mathematics education stems from confusion brought about when opinion is substituted for data and the treatment of tentative hypothesis as established conclusions. These aims should be in touch with reality and be strategically attainable. The aims of mathematics education at technikons therefore must be regarded as tentative hypotheses which have to be re-evaluated. These aims should be translated into operational goals so as to give mathematics education at technikons direction.

8. Cognisance should be taken of the knowledge explosion as well as related changes in technology with recognition being given by regular revision of the mathematics syllabi.

9. The revision of mathematics syllabi should only be expressed in terms of an acceptable curriculum change model adapted for technikon education.

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APPENDIX 1

THE QUESTIONNAIRE

PENINSULA TECHNIKON

DEPARTMENT MATHEMATICS AND STATISTICS

P.O. BOX 1906, BELLVILLE, 7535

REF

FOR OFFICE USE ONLY

QUESTIONNAIRE ON THE UTILITY VALUE OF MATHEMATICS FOR ELECTRICAL ENGINEERING IN THE WORKPLACE (INDUSTRY).

DESIGNATION	ENGINEER	MANAGER	LECTURER	TECHNICIAN	STUDENT
MARK EMPTY BLOCK WITH AN X	1	2	3	4	5

NAME & ADDRESS OF COMPANY	SURNAME	INIT.	AGE
	TELEPHONE	CODE	NUMBER

Q.1 Do you use the following topics in Mathematics for your calculations in the workplace?

TOPIC	OFTEN (once per week) 4	OCCASIO-NALLY 3	RARELY 2	NEVER 1
1.1 Complex numbers				
1.2 Trigonometric functions				
1.3 Hyperbolic functions				
1.4 Differentiation (ordinary)				
1.5 Intergration				
1.6 Differentiation (partial)				
1.7 Ordinary Diff. Equations				
1.8 Partial Diff. Equations				
1.9 Boolean algebra				
1.10 Numerical methods				
1.11 Statistics				
1.12 Indices				
1.13 Logarithms				
1.14 Vector analysis				
1.15 Matrix algebra				
1.16 OTHER				
1.16.1				
1.16.2				
1.16.3				

Q.2 GIVE EXAMPLES OF THE TYPES OF CALCULATIONS YOU DO:-

2(a) OFTEN

2(b)OCCASIONALLY

2(c) RARELY

Q.3 WHAT COMPUTING AIDS ARE YOU USING?

Q.4 WHAT MATHEMATICS MUST YOU KNOW TO USE COMPUTING AIDS IN Q.3 EFFECTIVELY?

Q.5 HAVE YOU INCLUDED EXAMPLES OF ABOVE IN Q.2?

YES	NO

Q.6 IF NO - PLEASE GIVE EXAMPLES FROM Q.4 NOT INCLUDED IN Q.2.

Q.7 HOW WOULD YOU RATE THE UTILITY VALUE OF THE FOLLOWING AREAS OF MATHEMATICS IN YOUR WORKPLACE ON A SCALE (1-10)
10 very high utility value

RATING :-	1	2	3	4	5	6	7	8	9	10
7.1 Classical Mathematics										
7.2 Boolean algebra										
7.3 Numerical methods										
7.4 Statistics										
7.5 ANY OTHER ______________										

Q.8 IF YOU ARE A TECHNICIAN OR STUDENT TECHNICIAN ARE YOU SATISFIED WITH THE MATHEMATICS YOU HAVE BEEN TAUGHT AT TECHNIKON?

YES	NO

Q.9 IF NO - COULD YOU ELABORATE?

____

____

____

____

____

____

Q.10 DO YOU ENVISAGE ANY CHANGE IN THE TYPE OF MATHEMATICS BEING USED IN FUTURE?

YES	NO

Q.11 IF YES - PLEASE ELABORATE

____

____

____

____

____

____

____

Q.12 ANY RELEVANT COMMENTS?

Q.13 IF YOU ARE A MANAGER AND/OR ENGINEER, WOULD YOU WANT YOUR TECHNICIANS TO HAVE THE BACKGROUND TO ASSIST PARTLY OR FULLY WITH CALCULATIONS AND MATHEMATICAL OPERATIONS AS YOU HAVE SHOWN IN 2(a), 2(b), 2(c) & 6 ABOVE?

YES	NO

Q.14 IF YES - TECHNICIANS SHOULD ASSIST IN CALCULATIONS

TYPE	PARTLY	FULLY
2(a)		
2(b)		
2(c)		
6		

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INSTRUCTIONAL OFFERING : ENGINEERING MATHEMATICS T1

CODE : 160400012

INSTRUCTIONAL PROGRAMME(S) :

N Dip : TOWN AND REGIONAL PLANNING 3202070
N Dip : INDUSTRIAL ENGINEERING 3208120
N Dip : ELECTRICAL ENGINEERING: HEAVY CURRENT 3208123
N Dip : ELECTRICAL ENGINEERING: LIGHT CURRENT 3208124
N Dip : AIR CONDITIONING AND REFRIGERATION 3208126
N Dip : MARINE ENGINEERING 3208127
N Dip : MATERIAL TESTING: CIVIL 3208128
N Dip : MECHANICAL ENGINEERING 3208129
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N Dip : PULP AND PAPER TECHNOLOGY 3208136
N Dip : CIVIL ENGINEERING 3208137
N Dip : HEAVY CLAY 3208139
N Dip : WELDING ENGINEERING 3208140
N Dip : CARTOGRAPHY 3208141
N Dip : TELECOMS 3208144
N Dip : GEOLOGY 3215170
Gen Cert : MARITIME RADIO COMMUNICATION 3208968

EXAMINATION : 1 x 3 HOURS

S Y L L A B U S

1. Algebra

   1.1 Indices

   1.2 Logarithms (log to the base a - special cases base e and base 10). Definition of log, graph and properties. Solution of logarithmic and exponential equations.

   1.3 Manipulation of formulae

   1.4 Binomial theorem (only series expansion)

   1.5 Determinants. (The use of second and third order determinants; Cramer's rule for solution of simultaneous equations)

2. Trigonometry

2.1 Radian measure - arc length, area of sector and segment of a circle

2.2 Fundamental identities

2.3 Solution of triangles; calculation of areas. The s-formula for areas

2.4 Inverse trigonometrical functions. Principal values.

2.5 Graphs (sketch) of $\sin\theta$, $\cos\theta$, $\tan\theta$ $(-2\pi \leq \theta \leq 2\pi)$

3. Co-ordinate geometry and graphs

3.1 Straight line:

3.1.1 Different forms

3.1.2 Length of a line

3.1.3 Angle between two lines

3.1.4 Conditions for perpendicularity and parallelism

3.2 Graphs (sketch) of the following:

$x^2 + y^2 = r^2$; $y = ax^2 + bx + c$; $xy = c$; $y = ax^3 + bx^2 + cx + d$;

$\frac{x^2}{a^2} \pm \frac{y^2}{b^2} = 1$

4. Complex numbers

4.1 Definition

4.2 Different forms

4.2.1 Rectangular form; operations - Argand diagram

5. Differential calculus

5.1 Concept of limits

5.2 Differentiation of elementary algebraic functions from first principles

5.3 Differentiation of the following standard forms

(i) kx^n; (ii) e^x; (iii) a^x; (iv) $\log_e x$ (lnx)
(v) Six trigonometric functions i.e. sinx; cosx; tanx; cosecx; secx; cotx.

5.4 Differentiation rules:

(i) Sum and difference; (ii) Product; (iii) Quotient;
(iv) Chain

5.5 Successive differentiation

5.6 Applications of differentiation

(i) Gradient
(ii) Maximum and minimum; points of inflexion of given functions and curve sketching. Simple cases.

6. Integral calculus

6.1 Integration of previously differentiated functions mentioned in 5.3

6.2 Definite integral

6.3 Areas between a single positive function and x-axis

INSTRUCTIONAL OFFERING	:	ENGINEERING MATHEMATICS T2
CODE	:	160400122
INSTRUCTIONAL PROGRAMME(S)	:	N Dip : INDUSTRIAL ENGINEERING 3208120 N Dip : ELECTRICAL ENGINEERING: HEAVY CURRENT 3208123 N Dip : ELECTRICAL ENGINEERING: LIGHT CURRENT 3208124 N Dip : AIR CONDITIONING AND REFRIGERATION 3208126 N Dip : MECHANICAL ENGINEERING 3208129 N Dip : SURVEYING 3208133 N Dip : CIVIL ENGINEERING 3208137 N Dip : WELDING ENGINEERING 3208140 N Dip : CARTOGRAPHY 3208141 N Dip : TELECOMS 3208144 Gen Cert : MARITIME RADIO COMMUNICATION 3208968
EXAMINATION	:	1 x 3 HOURS

S Y L L A B U S

1. Hyperbolic functions

   1.1 Exponential form of complex numbers

   1.2 Definitions; graphs and identities

   1.3 Inverse hyperbolic functions

2. Differential calculus

   2.1 Implicit functions (1st and 2nd derivatives)

   2.2 Logarithmic differentiation

   2.3 Inverse trigonometric functions

   2.4 Hyperbolic functions

   2.5 Inverse hyperbolic functions

   2.6 Parametric functions (1st and 2nd derivatives)

   2.7 Partial differentiation

2.8 Applications of differential calculus

2.8.1 Velocity and acceleration (linear and rotational)

2.8.2 Practical applications of maximum and minimum

2.8.3 Application of partial differentiation - increments, percentage error, related rates

3. Series

Taylor and Maclaurin series. Expansion of elementary functions.

4. Integral calculus

4.1 Elementary substitutions and techniques

4.2 Trigonometric functions (powers and products). (Reduction formula excluded)

4.3 Integration by parts

4.4 Trigonometric substitutions for $a^2 \pm x^2$

4.5 Hyperbolic substitution for $x^2 - a^2$

4.6 The following types:

$$\int \sqrt{ax^2 + bx + c}\ dx$$

$$\int \frac{dx}{\sqrt{ax^2 + bx + c}}$$

$$\int \frac{(Ax+B)}{\sqrt{ax^2 + bx + c}}\ dx$$

$$\int (Ax+B)\sqrt{ax^2 + bx + c}\ dx$$

4.7. Partial fractions
The following types:

$$\int \frac{A\ dx}{(ax+b)(cx+e)}$$

$$\int \frac{A}{(ax+b)^n}\ dx$$

$$\int \frac{(Bx+c)\ dx}{(ax^2 + bx + c)(cx+f)}$$

$$\int \frac{(Bx+c)\ dx}{(ax^2 + bx + c)^n}$$

4.8 Applications of integration

More difficult problems on areas (e.g. between two curves); mean and R.M.S. values of algebraic and trigonometric functions; volume of solids of revolution

4.1 Short D-operator methods

4.2 Applications

5. Simultaneous differential equations

6. Laplace transforms

6.1 Definitions of the transform process

6.2 Transform of elementary functions

6.3 Transform of impulse, step, ramp and acceleration functions

6.4 Transform of derivatives

6.5 Use of table of Laplace transforms

6.6 Solution of differential equations with stated initial conditions

INSTRUCTIONAL OFFERING : Engineering Mathematics T4

CODE : 160400306

INSTRUCTIONAL PROGRAMME : N.H.Dip : Electrical Engineering - Heavy Current 3508225

: N.H.Dip : Electrical Engineering - Light Current 3508226

: N.H.Dip : Mechanical Engineering - 3508230

: N.H.Dip : Telecommunications 3508241

: N.H.Dip : Aviation 3508322

EXAMINATION : 1 x 3 HOUR

SYLLABUS

1. FOURIER SERIES

   1.1 Series valid over a range with period 2L
   1.2 Expansion of simple functions over a half range in sine and cosine series
   1.3 Harmonic analysis from tabulated values of a function

2. COMPLEX VARIABLES

   2.1 Functions of complex variables
   2.2 Differentiation

      2.2.1 Differentiation of a function of a complex variable
      2.2.2 Cauchy-Riemann conditions

   2.3 Integration

      2.3.1 Line and contour integration
      2.3.2 The Cauchy-Goursat Theorem
      2.3.3 Cauchy integral formula

   2.4 Series

      2.4.1 The Taylor series
      2.4.2 The Laurent series
      2.4.3 Residue
      2.4.4 Residue Theorem

   2.5 Conformal mappings

      2.5.1 The functions $\frac{1}{z}$; z^n; $\sqrt{z}$
      2.5.2 The transformations $w = e^z$, $w = \sin z$

3. PARTIAL DIFFERENTIAL EQUATIONS (ONLY TWO INDEPEND
VARIABLES)

3.1 Method of separation of variables
3.2 Method of Laplace Transforms
3.3 Method of Fourier Sine- and Cosine-transforms
3.4 Special references to:

3.4.1 The heat-flow equation
3.42 The vibrating-string equation
3.4.3 Laplace equation in rectangular and po
coordinates

3.5 Only unique solutions

3. PARTIAL DIFFERENTIAL EQUATIONS (ONLY TWO INDEPENDENT VARIABLES)

3.1 Method of separation of variables
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3.4 Special references to:

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3.42 The vibrating-string equation
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3.5 Only unique solutions

APPENDIX 3

PROPOSED MATHEMATICS SYLLABI AND GUIDES

I N D E X

PAGE

APRIL 1988

CONCEPT SYLLABUS: ENGINEERING MATHEMATICS T1 CODE: 16....

1. ALGEBRA

1.1 LOGARITHMS

1.2 QUADRATIC EQUATIONS

1.3 MANIPULATION OF FORMULAE

1.4 PARTIAL FRACTIONS

1.5 BINOMIAL THEORUM

2. TRIGONOMETRY

2.1 RADIAN MEASURE

2.2 GENERAL EQUATIONS OF THE SINE FUNCTION

2.3 SUPER-IMPOSITION OF TWO SINE WAVES

2.4 TRIGONOMETRIC IDENTITIES

2.5 TRIGONOMETRIC EQUATIONS

3. CALCULUS

3.1 DIFFERENTIATION

3.2 INTEGRATION

4. OPTION

COMPLEX NUMBER OR

COORDINATE GEOMETRY

5. MATRICES AND DETERMINANTS

LECTURERS GUIDE APRIL 1988

ENGINEERING MATHEMATICS T101 CODE: 16....

MIN. CONTACT TIME: 65 HRS

EXAMINATION: 1 X 3 HRS

LECTURERS GUIDE

The following text books are used as references:

(A) Wiskunde vir Tegnici - C.L. du Plessis - (McGraw-Hill 1983)

(B) Engineering Mathematics - K.A. Stroud - (Macmillan 1981)

(C) Theory and problems of matrices - Frank Ayres - Schaums.

(D) Vector Analysis - Murray Spiegel.

Note well that text references only indicate the depth and standard of the instructional offering and should not be seen as prescribed texts. Each technikon has the freedom to select text books of their preference.

1. ALGEBRA (2 weeks)

1.1 LOGARITHMS

Definition (A: p31); Logarithmic and exponential form (A: p32); Laws (A: p34); Graph of y = log x (A:p36); Change of base (A: p41); Natural logarithms (A: p43).

1.2 Quadratic Equations

Solutions:- factorization (A: p47); The formula (A: p49).

1.3 Manipulation of formulae

Four basic manipulations, powers and roots, exponential and logarithmic manipulations as well as examples involving trigonometric functions (any Std. 10 text book).

1.4 Partial Fractions

Limited to linear factors (B: p373); repeated linear factors (B: p375) and quadratic factors (B: p377).

1.5 Binomial Theorum

Only as applicable to Differentiation: (A: p84; B: p337).

2. Trigonometry (1 week)

2.1 Radian Measure

Definitions (A: p144); Relationship between arc-length and angle (A: p145); areas of sectors and segments (A: p152).

2.2 General equation of the sine function

y = R sine (wt +); Graphs of latter.

2.3 Superposition of two sine waves.

2.4 Trigonometric Identities

2.5 Trigonometric Equations

(A: p116).

3. CALCULUS (5 weeks)

3.1 Differentiation

3.1.1 The concepts: functions (A: p195); limits (A: p200); differentiation from first principles (A: p214); derivative as a gradient (A: p216).

3.1.2 Revision of the rules of differentiation (for students who have been exposed at school) (A: p230 & B: pp177-178).

3.1.3 Implicit differentiation (B: pp185 & 285); A: p.247); logarithmic differentiation (A: p252; B; p180).

3.1.4 Applications of differentiation: Turning points and curve sketching (A: p263; B: p235); velocity and accelleration.

3.1.5 Solution of non-linear equations (Newton-Raphson) (A: p321).

3.2 Integration

3.2.1 Simpson's rule (A: p327 & B: p523); the integral and area (A: pp306-310 & B: pp435-437).

3.2.2 Integration as inverse to differentiation

3.2.3 Integration techniques: Polynomials, trigonometric functions, logarithmic functions, exponential functions. (A: pp287; B: pp357).

3.2.4 Applications: Options in the electrical- and mechanical technology.

4. **<u>OPTION</u>: COMPLEX NUMBERS OR COORDINATE GEOMETRY** (2 weeks)

4.1 Complex numbers (A: pp59-; B: pp4-).

4.2 Coordinate geometry (A: pp158--).

5. **<u>MATRICES AND DETERMINANTS</u>** (2 weeks)

5.1 Matrices (C: pp1-3)
Definition; square; equivalent; nil-matrix; +; -; x.

5.2 Some types of matrices (C: pp10-11).

Identify-; diagonal-; upper- and lower triangle matrix; inverse- and transposed matrices.

5.3 Determinants of square matrices (C: Chpt. 3)

Definition; order; minors; co-factors.

5.4 Evaluation of determinants (C: p33).

Up to third order determinants making use of minors of 3x3 determinants.

5.5 Linear equations (C: p72)

Solution using Cramer's rule.

5.6 Vectors in 3-dimension.

5.6.1 Scalars and vectors:-

Scalers	(D: p1)
Laws of vector algebra	(D: p2)
Unit vectors	(D: p2)
Components	(D: p3)

5.6.2 Dot- and cross-product:

Laws	(D: p16)

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ENGINEERING MATHEMATICS T2 CODE: 16......

MIN CONTACT TIME: 65 HRS

EXAMINATION: 1x3 HOUR PAPER

REFERENCES

A: STROUD K.A.: ENGINEERING MATHEMATICS
(SECOND EDITION) MACMILLAN 1982
ISBN: 0 333 33337 3

B: ELZEY F.F.: A PROGRAMME INTRODUCTION TO STATISTICS
BROOKS/COLE PUBLISHING COMPANY, 1971
ISBN: 0 8058 0018 2

TOPIC	REFERENCE
Differentiation:	
Revision of T1 work	A:pp 219-235
Derivatives of inverse trig functions	A:pp 271-277
Parametric functions first and second derivatives	A:pp 235-238
Applications eg. vel. accel. rate of cooling etc.	A:pp 295-297
Practical examples of differential equations.	
Partial Differentiation	
First order partial derivatives of functions of two or more variables	A:pp 299-324
Second order partial derivatives of functions of two variables only	A:pp 325-344
Series	
Maclaurin's series	
Verification of: $\cos 0 + j \sin 0 = e^{j0}$	A:pp 425-438

Integration

Revision of Tl work
Simple substitution
Integration by parts
Partial fractions
Integration of trig functions
Powers of sin x and cos x
Integrals of the form (cos ax) X (Sin bx) A:pp 455-486

Solution of first order differential equations

Separation of variables
Homogeneous equations
Reducable to homogeneous A:pp 691-711

Numerical methods

Accuracy and errors
Effects of errors on calculations
Simultaneous linear equations
Numerical differentiation
Rectangular rule
Trapezoidal rule

Statistics

Organization of data: Frequency distributions	B:pp	1- 19
Measures of central tendency: Mode, Median, Mean	B:pp	20- 48
Comp. of measures of central tendency: Percentiles	B:pp	49- 64
Graphic representation of frequency distributions	B:pp	65-78
Measures of variability: Range		
Semi-inter-quartile range		
Average deviation		
Variance		
Standard Deviation	B:pp	79-103

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ENGINEERING MATHEMATICS TIO3

CODE: 16......

CONCEPT SYLLABUS

1. LaPlace Transforms

2. Fourier Series and Fourier Analysis

3. Linear Algebra

4. First Order Differential Equations

5. Higher Order Linear Differential Equations

6. Numerical solution of Differential Equations

APRIL 1988

LECTURERS GUIDE

CODE: 16......

ENGINEERING MATHEMATICS TIO3

MIN CONTACT TIME: 75 HRS

EXAMINATION: 1x3 HRS PAPER

RECOMMENDED TEXT BOOKS:

Stroud I : Engineering Mathematics, K A Stroud

Stroud II: Further Engineering Mathematics. K A Stroud

1. LAPLACE TRANSFORMS — 3 weeks, Stroud II: Programmes 7 & 8

1.1 Definition

1.2 Standard transforms including impulse and unit step functions - no derivations for examination purposes.

1.3 Transforms of derivatives - no derivation for examination purposes.

1.4 Use of tables with transform pairs.

1.5 Solution of differential equations using Laplace transforms.

2. FOURIER SERIES AND FOURIER ANALYSIS — 3 weeks, Stroud II: Programmes 17 & 18

2.1 Series valid over a range with period 2L.

2.2 Half range sine and cosine series.

2.3 Harmonic analysis of tabulated results.

3. **LINEAR ALGEBRA** — 2 weeks
Stroud II:
Programme 11

3.1 Eigen values and Eigen vectors.

3.2 Numerical treatment and applications of the above.

4. **FIRST ORDER DIFFERENTIAL EQUATIONS** — 3 weeks
Stroud II:
Programme 22

4.1 Homogeneous and reducible types

4.2 The type $\frac{dy}{dx} = \frac{m(ax + by) + c}{n(ax + by) + e}$

4.3 Bernoulli's equation.

4.4 Applications - engineering related problems in Heat conduction, exponential growth and decay and LR and RC circuits.

5. **HIGHER ORDER LINEAR DIFFERENTIAL EQUATIONS** — 2 weeks
Stroud I:
Programme 23

5.1 D-operator methods.

5.2 Applications: mechanical vibrations and electrical circuits.

6. NUMERICAL SOLUTION OF DIFFERENTIAL EQUATIONS — 2 weeks — Stroud II: Programme 6

(First and Second Order)

6.1 Euler Method

6.2 Runge-Kutta

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ENGINEERING MATHEMATICS TIO4

CODE: 16......

OPTIONS

1. PARTIAL DIFFERENTIAL EQUATIONS (COMPULSORY) ±30 HRS
(1 x 1½ HR EXAMINATION)

2. ONE OF THE FOLLOWING OPTIONS
(1 x ½ HR EXAMINATION) ±30 HRS

   2.1 STATISTICS

   2.2 FINITE ELEMENT METHODS

   2.3 Z-TRANSFORMS

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ENGINEERING MATHEMATICS TIO4

CODE: 16......

CONCEPT SYLLABUS

1. PARTIAL DIFFERENTIAL EQUATIONS (COMPULSORY) ±30 HRS

1.1 METHOD OF SEPERATION OF VARIABLES

1.2 METHOD OF LAPLACE - TRANSFORMS

1.3 METHOD OF FOURIER SINE AND COSINE TRANSFORMS

1.4 APPLICATIONS TO ENGINEERING

APRIL 1988

LECTURER GUIDE

ENGINEERING MATHEMATICS TIO4 CODE: 16......

1. PARTIAL DIFFERENTIAL EQUATIONS (30 HOURS)

REFERENCE BOOKS

A. THEORY AND PROBLEMS OF LAPLACE TRANSFORMS BY MURRAY R. SPIEGEL (SCHAUM'S OUTLINE SERIES)

B. THEORY AND PROBLEMS OF FOURIER ANALYSIS BY MURRAY R. (SCHAUM'S OUTLINE SERIES)

C. AN INTRODUCTION TO PARTIAL DIFFERENTIAL EQUATION FOR SCIENCE STUDENTS (SECOND EDITION) BY G STEPHENSON (LONGMAN)

D. FURTHER ENGINEERING MATHEMATICS BY K A STROUD (FIRST EDITION) 1986

1. PARTIAL DIFFERENTIAL EQUATIONS (30 HRS)

ONLY TWO INDEPENDENT VARIABLES

1.1 METHOD OF SEPERATION OF VARIABLES

1.1.1 Typical problems

C page 30: example 1
47: example 1
50: example 2 & 3
63: paragraph 5.2
66: example 1

B page 15: 1.23 & 1.24
19: 1.43(c), (d) & (g) & 1.44
42: 2.30

D: pp 992 - 1024

1.2 METHOD OF LAPLACE TRANSFORMS

1.2.1 Definition of the error function: $\text{erf } x = \frac{2}{\sqrt{\pi}} \int_0^x e^{-u^2} du$.

1.2.2 Definition of the complimentary error function
$\text{erfc } x = 1 - \text{erf } x$

1.2.3 $L \{\text{erfc } \frac{a}{2\sqrt{x}}\} = \frac{e^{-a\sqrt{p}}}{p}$ (proof not required) c 98 Par. 7.4

1.2.4 Transforms of partial derivatives (two independent variables) c 108 Par. 8.2

1.2.5 Typical problems

(Laplace-transforms will be provided in the exam.

C. page 112: examples 3,4 & 5
A page 97: 25 & 26
108: 86 & 88
221: 1
224: 4

1.3 METHOD OF FOURIER SINE - AND COSINE TRANSFORMS

1.3.1 Definition of transforms and inverse transforms

1.3.2 Transforms of partial derivatives C 118 Par. 8.3

1.3.3 Typical problems

(1) C. page 120: example 7

(2) Solve $\frac{\partial^2 u}{\partial x^2} = \frac{1}{k} \frac{\partial u}{\partial t}$ subject to: $u(x;0) = e^{-x^2}$

and $\frac{u}{x}$ (0;t) = 0 by means of Fourier-cosine transform w.r.t. x

HINT:- $F_c\{\frac{\partial^2 u}{\partial x^2}(x;t)\} = -p^2 u_c(p;t) - \frac{\partial u}{\partial x}(0;t)$

$$\int_0^\infty e^{-ay^2}\cos by\,dy = \frac{1}{2}\sqrt{\frac{\pi}{a}}\,e^{-b^2/4a}$$

Ans: $u(x;t) = \frac{1}{\sqrt{1+4kt}}\,e^{-\frac{x^2}{1+4kt}}$

(3) Solve: $\frac{\partial^2 u}{\partial x^2} = 4\frac{\partial u}{\partial t}$ subject to:

u (o;t) = o

u (x;o) = x e^{-x^2} by a Fourier-sine-transform

with respect to x Hint: $F_s\{\frac{\partial^2 u}{\partial x^2}(x;t)\} = -p^2\bar{u}_s(p;t) + pu(o;t)$

$$\int_0^\infty e^{-ay^2}\cos by\,dy = \frac{1}{2}\sqrt{\frac{\pi}{a}}\,e^{-b^2/4a}$$

Ans: $u(x;t) = \frac{x}{(1+t)^{3/2}}\,e^{-\frac{x^2}{1+t}}$

1.5 Candidate must be able to calculate the numerical value of the unique solution.

Given: $u(x;t) = \frac{A_0}{2} + \sum_{r=1}^{\infty} A_r \left(\cos \frac{r\pi x}{a}\right) e^{-r^2\pi^2 kt/a}$

Where: $A_o = \frac{2}{a} \int_0^a f(x) \, dx$

and $A_r = \frac{2}{a} \int_0^a f(x) \cos \frac{r\pi x}{a} \, dx$

determine u (0;1) as a = 4; k = 0,1 and f (x) = x

Answer: u (0; 1) = 0,357

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ENGINEERING MATHEMATICS TIO4

CODE: 16......

CONCEPT SYLLABUS OPTION 2.1

2.1	STATISTICS (OPTIONAL)	±30 HRS
2.1.1	PROBABILITY THEORY	
2.1.2	RANDOM VARIABLES	
2.1.3	SPECIAL DISTRIBUTIONS	
2.1.4	HYPOTHESIS TESTING AND CONFIDENCE ESTIMATES	
2.1.5	REGRESSION: LINEAR & MULTIPLE	
2.1.6	CORRELATION	
2.1.7	ANALYSIS OF VARIANCE	

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LECTURERS GUIDE

CODE: 16.......

STATISTICS (ENGINEERING MATHEMATICS T4)

MIN CONTACT TIME: 30 HRS

EXAMINATION: 1x1½ HR PAPER

REFERENCE BOOKS

J E FREUND 1984
Modern Elementary Statistics Sixth Edition
Englewood Cliffs, New Jersey (F)

CANGELOSI, TAYLOR, RICE 1983
Basic Statistics - A real world approach.
Third Edition (CTR)

TOPIC	REFERENCES CTR	REFERENCES F
1.1 Probability Theory	65 - 94	
1.2 1.2.1 Random Variables	94 - 96	167 - 168
1.2.2 Probability Distributions	96 - 98	168 - 169
1.2.2.1 Uniform	98 - 99	
1.2.2.2 Binomial	99 - 102	170 - 177
1.2.2.3 Poisson	104 - 107	180 - 182

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ENGINEERING MATHEMATICS T4

CODE: 16.......

CONCEPT SYLLABUS FINITE ELEMENT ANALYSIS

OPTION: 2.2

1. Review of matrix algebra

2. Basic concepts

3. The concept of stiffness analysis

4. Bar finite elements

5. Finite elements of continua

6. Triangular finite element for plane elasticity

7. Rectangular finite element for plane elasticity

8. Rectangular finite element for plate flexure

9. Analysis of folded-plate, box-girder and shell structures using rectangular elements

10. Axially summetric continua

11. Programming

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LECTURERS GUIDE

CODE: 16.......

FINITE ELEMENTS METHODS (ENGINEERING MATHEMATICS TIO4)

MIN CONTACT TIME: 30 HRS

EXAMINATION: 1x1½ HR PAPER

TEXT BOOK (PRESCRIBED)

The Finite Element Method

A Basic Introduction for Engineers (2nd Ed)

K.C. Rockey, H R Evans, D W Griffiths and D A Nethercot - Granada

		PAGE
1.	**REVIEW OF MATRIX ALGEBRA**	227
2.	**BASIC CONCEPTS**	1
2.1	Fundamental requirements	
2.2	Stiffness and flexibility methods of matrix analysis	
2.3	Principle of virtual work	
3.	**THE CONCEPT OF STIFFNESS ANALYSIS**	7
3.1	An introduction to stiffness analysis	
3.2	Stiffness matrix for single elastic spring	
3.3	Stiffness matrix for assembly of springs	
3.4	Applications to frameworks	

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LECTURERS GUIDE

CODE: 16.......

Z TRANSFORMS (ENGINEERING MATHEMATICS TIO4)

MIN CONTACT TIME: 30 HRS

EXAMINATION: 1x1½ HR PAPER

A: METHODS OF DISCRETE SIGNAL AND SYSTEM ANALYSIS BY
M T JONG
MCGRAW-HILL ISBN 0-07-033025-5

B: DIGITAL CONTROL SYSTEM ANALYSIS AND DESIGN BY
C L PHILLIPS & H T NAYLE
PRENTICE-HALL ISBN 0.13.212043-7

	A	B
INTRODUCTION	1.1 - 1.8	
DISCRETE SIGNALS AND SYSTEMS		1.0 - 1.6
DIFFERENCE EQUATIONS		2.0 - 2.7
DISCRETE TIME SYSTEMS	2.2	
CONVOLUTION TECHNIQUES		3.1 - 3.8
THE Z - TRANSFORM	2.3 - 2.4	5.1 - 5.4
SOLUTION OF DIFFERENCE EQUATIONS	2.5	5.6
THE INVERSE Z TRANSFORM	2.6	5.5
SIMILATION DIAGRAMS AND FLOW GRAPHS	2.7	5.6

	A	B
STATE VARIABLES: FORMULATION & SOLUTION	2.8 - 2.12	6.0 - 6.12
SAMPLED DATA SYSTEMS	3.1 - 3.2	6.13
THE IDEAL SAMPLER	3.3	
DATA RECONSTRUCTION	3.6	
PULSE TRANSFER FUNCTION	4.3	
MODIFIED Z - TRANSFORM	4.5 - 4.6	
NONSYNCHRONOUS SAMPLING	4.7	

SHOULD BE A CHOICE BETWEEN Z TRANSFORMS & FINITE ELEMENT ANALYSIS FOR ELECTRICAL, MECHANICAL AND CIVIL ENGINEERING

APPENDIX 4

EXTRACT OF LOGBOOK

SUMMARY OF IN-SERVICE TRAINING		Month No. ....
Employer: .... Postal Address: .... Telephone No. .... Postal Code	Student Name .... Postal Address .... Postal Code .... Telephone	From: To:

Description of tasks performed

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Performance Appraisal (Scale 1-10)	Comments from Supervisor	Comments from Student
Quality of work ☐ Quantity of work ☐ Responsibility ☐ Knowledge and skills ☐ Motivation ☐ Communication ☐	....	.... Signed ..... Date
Signed .... Designation .... Date		

APPENDIX 5

RELEVANT ELECTRICAL ENGINEERING SYLLABI

I N D E X

INSTRUCTIONAL OFFERING : DIGITAL SYSTEMS T1

CODE : 080800112

INSTRUCTIONAL PROGRAMME(S) : N Dip : ELECTRICAL ENGINEERING: HEAVY CURRENT 3208123
N Dip : ELECTRICAL ENGINEERING: LIGHT CURRENT 3208124
N Dip : TELECOMS 3208144
N Dip : METEOROLOGY 3222187
Gen Cert : MARITIME RADIO COMMUNICATION 3208968

EXAMINATION : 1 x 3 HOURS

S Y L L A B U S

1. Analog vs digital signals and computation

   Analog and digital signals: accuracy and speed of computation

2. Number systems and binary codes

   Number systems; conversion from one system to another; complements; arithmetic; selected binary codes; parity; Baudot, ASC II and EBCDIC codes

3. Switching algebra and minimization

   Logic functions; truth tables; Karnaugh map; Boolean algebra; selected combinatorial circuits

4. Flipflops, counters and registers

   Various types of flipflops; ripple counters; shift registers

5. Stored program digital computer

   Block diagram of stored program computer, CPU, storage, I/O and peripheral devices; characteristics of discs, tapes, drums, printers, card and tape readers and punches; MICR; OCT; VDU; plotters; machine, assembler and high level languages; A/D to D/A conversion

INSTRUCTIONAL OFFERING	:	ELECTRONICS T1
CODE	:	080802212
INSTRUCTIONAL PROGRAMME(S)	:	N Dip : ELECTRICAL ENGINEERING: HEAVY CURRENT 3208123 N Dip : ELECTRICAL ENGINEERING: LIGHT CURRENT 3208124 N Dip : EXPLOSIVES TECHNOLOGY 3208135 N Dip : TELECOMS 3208144 N Dip : METEOROLOGY 3222187 Gen Cert : MARITIME RADIO COMMUNICATION 3208968
EXAMINATION	:	1 x 3 HOURS

S Y L L A B U S

1. Semiconductor theory

   Bohr model; valency and free electrons; conductors, semiconductors, insulators; Xtal structure; covalent bonds; doping; intrinsic and extrinsic doping; donors and acceptors; minority and majority carriers; effects of light and temperature

2. The P-N diode

   The p-n junction; forward and reverse bias; junction potential and capacitance; diode characteristic; effect of temperature; load line; diode as rectifier; half and full wave rectification; peak inverse voltage; diodes in series and parallel

3. Single stage junction transistor amplifier

   Operation of junction transistor; three basic configurations; voltage and current gain; relationship between alpha and beta; bias and thermal stability; load line; gain in dB: class A, B and C amplifiers

4. Single stage field effect transistor amplifier

   Construction of JUGFET and MOSFET; characteristic; load line; comparison of FET and BJT

5. Ideal operational amplifier

Characteristics of an "ideal" op-amp; differential input; gain related to negative feedback; use as adder, comparitor, voltage follower

6. The oscilloscope

Thermionic emission, the triode; the cathode ray tube; electrostatic and magnetic deflection; block diagram of oscilloscope; use of oscilloscope

7. First order networks

R-C and L-C networks with sine and square wave inputs; transfer function; attenuation and phase shift; bode diagram

INSTRUCTIONAL OFFERING : ELECTRICAL ENGINEERING T1

CODE : 080803012

INSTRUCTIONAL PROGRAMME(S) :

N Dip	:	INDUSTRIAL ENGINEERING 3208120
N Dip	:	ELECTRICAL ENGINEERING: HEAVY CURRENT 3208123
N Dip	:	ELECTRICAL ENGINEERING: LIGHT CURRENT 3208124
N Dip	:	AIR CONDITIONING AND REFRIGERATION 3208126
N Dip	:	MARINE ENGINEERING 3208127
N Dip	:	MECHANICAL ENGINEERING 3208129
N Dip	:	PULP AND PAPER TECHNOLOGY 3208136
N Dip	:	HEAVY CLAY 3208139
N Dip	:	WELDING ENGINEERING 3208140
N Dip	:	TEXTILE TECHNOLOGY: DRY PROCESSING 3208142
N Dip	:	TEXTILE TECHNOLOGY: WET PROCESSING 3208143
N Dip	:	TELECOMS 3208144
Gen Cert	:	MARITIME RADIO COMMUNICATION 3208968

EXAMINATION : 1 x 3 HOURS

S Y L L A B U S

1. SI units and energy

1.1 Scientific notation; metric prefixes, use of symbols, abbreviations etc. and writing rules; Greek letters used as symbols; meaning and use of symbols such as $\simeq$, $<<$, $\propto$, etc.

1.2 Units to be dealt with in a logical sequence as each aspect is covered

1.3 Explanations instead of formal definitions of units preferred. Sections 1, 2 and 3 to be done in tandem since they form one entity

1.4 The electric circuit

1.4.1 Properties and requirements of more commonly used conductors, insulating materials and alloys; use of wire gauges and tables

1.4.2 Units of quantity and current; effects of current; subsequent applications

1.4.3 Concept of emf, pd, power and resistance; units

1.4.4 Ohm's Law; elements with non-linear V/I characteristics.

1.4.5 Resistivity and conductivity; effects of temperature change on resistivity as applied to 1.4.1; units and definitions; practical significance, applications etc.

1.4.6 Energy conversion; units of force, energy, power, torque; energy conversion; relationships, power losses and efficiency

1.4.7 Cells: elementary theory, constructional details, capacity, efficiency, fields of application, installation, operation, maintenance and comparison of modern primary and secondary cells; internal resistance; equivalent circuit; practical circuit connections

2. Network analysis

Static and dynamic direct and alternating voltage sources; comparison; concepts of: voltage regulation, equivalent circuit or steady state model; resistances in series, parallel and compound circuits; Kirchhoff's laws, mesh connections; concept of an alternating waveform, frequency, period, wavelength, phase displacement; average, rms values, form factor and peak factor of periodic voltages and currents

3. Magnetism

3.1 The magnetic field

3.2 Properties, characteristics, detection, direction and production; force and torque on a current-carrying conductor; applications; unit and definition of flux density

3.3 Practical magnetic circuits

3.4 Definitions, units and relationships of magnetic force, magnetomotive force (m.m.f.), reluctance, permeance, relative and absolute permeability; leakage and fringing leakage factor. B/H curve and hysteresis loop; comparison, requirements, application and properties of different types of ferro-magnetic materials

Hysteresis and eddy current loss; force exerted by electromagnet on a magnetic material, applications

4. Inductance

4.1 Electromagnetic induction

4.2 Faraday's and Lenz's Laws, dynamic and static emf generation, applications; cumulative and buck connections of inductors (reactors, choke coils), self and mutual inductance; units and definition of flux and inductance; energy stored and dissipated; concept of exponential growth and decay of current; graphical representation of emf under varying current conditions

5. Capacitance

concept of capacitance and charge storage; unit and definition; capacitors; types, capacitors in series, parallel and series-parallel combinations; electric force or potential gradient; electric flux density: permittivity of free space, relative permittivity or dielectric constant; capacitance as dependent upon dimensions of capacitor; charge and discharge of a capacitor; energy stored and dissipated; concept of exponential growth and decay of current and voltage; graphical representation of current under varying voltage conditions

6. Alternating current circuits

Production of alternating emf in a coil rotated in a uniform magnetic field; instantaneous emf equation; relationship between pole pairs, speed and frequency; phasor representation; components, complex notation; summation of phasors; concept of ideal (pure) R-L-C circuit elements connected to an alternating voltage supply; practical elements; inductive and capacitive reactance, impedance, power and pf; analysis of series circuits; phasor diagrams

7. Measuring instruments

Essential features of analogue instruments; construction and principles of operations of PMMC and dynamometer instruments; direct and alternating measuring multimeters; sensitivity; standard markings; extension of ranges; ohmmeter and megger; measurement of resistance using Wheatstone bridge, ohmmeter, megger and voltmeter/ammmeter method; the slide wire potentiometer and its applications

INSTRUCTIONAL OFFERING : INDUSTRIAL INSTRUMENTS TI

CODE : 081500012

INSTRUCTIONAL PROGRAMME(S) : N Dip : ELECTRICAL ENGINEERING: HEAVY CURRENT 3208123
N Dip : ELECTRICAL ENGINEERING: LIGHT CURRENT 3208124

EXAMINATION : 1 x 3 HOURS

SYLLABUS

1. Introduction to instrumentation

   1.1 Purpose of measurement and control in industrial processes, field of application of industry

   Instrumentation flow plan symbols as per I.S.A. publication S5.1 (1973)

   1.2 Concepts and definition of terms such as accuracy, precision, conformity of a curve, hysteresis, linearity, repeatability, reproducibility, resolution, sensitivity to be dealt with whenever applicable in each of the following sections

2. Measurement of pressure

   2.1 Units of pressure in the S.I. system, types of pressure, methods of measurement, manometers, simple calculations

   2.2 Bourdon tube, diaphragm and bellows activated instruments. Protection against overranging. Calibration adjustments. Pulsation damping

   2.3 Test instruments. Hydrostatic test balance, master gauge. Simple calculations

3. Measurement of flow rate and flow volume

   3.1 Flow units in the S.I. system, differential pressure method: simple theory and descriptive treatment of primary elements and differential pressure transmitters (pneumatic and electronic). Flow indicators

3.2 Positive displacement meters for liquids: reciprocating piston, oscillating piston, nutating disc, rotating vane, helical vane, turbine meter

3.3 Wet and dry gas meters

4. Measurement of level and content

General description of direct methods, pressure measurement methods, buoyance methods

5. Measurement of temperature

5.1 Units of temperature in the S.I. system, instruments for measuring temperature: expansion methods, change of state methods, pyrometric cones

5.2 Electrical methods: resistance bulbs, thermocouples, simple wheatstone bridge and potentiometer circuits (basic circuits)

6. Automatic process control

6.1 Description of basic concepts. Block diagram of closed loop system

6.2 Types of controllers

6.3 Control valves and valve positioners

7. Measurement of physical properties

7.1 Relative density of liquids

7.2 Viscosity of liquids

7.3 Mass measurement

8. Laboratory work

INSTRUCTIONAL OFFERING : INDUSTRIAL TECHNOLOGY (L.C.) T1

CODE : 080804312

INSTRUCTIONAL PROGRAMME(S) : N Dip : ELECTRICAL ENGINEERING: HEAVY CURRENT 3208123
N Dip : ELECTRICAL ENGINEERING: LIGHT CURRENT 3208124

EXAMINATION : 1 x 3 HOURS

SYLLABUS

1. Workshop practice

   Safety; shop tools e.g. drilling machines, saws, guillotine, bending brake, grinding wheel, marking out tools; sheet metal work

2. Materials technology

   Steel; carbon steel; copper; aluminium; alloys; magnetic materials; conductors, insulators, resistor materials; plastics; epoxy glasses; adhesives

3. Components

   Resistors; potentiometers; capacitors; inductors; transformers; semiconductor devices; integrated circuits; switches; relays

4. Connectors

   Crimp and solder lugs; edge connectors; ribbon cable connectors; coax connectors; sockets; heat shrink tubing

5. P.C. boards

   Board preparation; resists; exposure and developing; etching; drilling; final finishing

6. Soldering

Soldering iron, solder and cored solder; flux; electronic circuit assembly

7. Wirewrapping

Wirewrapping terminology and techniques

8. Electronic draughting

Draughting equipment; lettering; geometric construction; views; dimensioning; symbols; diagrams; chassis drawings

INSTRUCTIONAL OFFERING : ENGINEERING MECHANICS T1

CODE : 081000012

INSTRUCTIONAL PROGRAMME(S) : N Dip : INDUSTRIAL ENGINEERING 3208120
N Dip : ELECTRICAL ENGINEERING: HEAVY CURRENT 3208123
N Dip : AIR CONDITIONING AND REFRIGERATION 3208126
N Dip : MARINE ENGINEERING 3208127
N Dip : MECHANICAL ENGINEERING 3208129
N Dip : METALLURGICAL ENGINEERING 3208131
N Dip : PULP AND PAPER TECHNOLOGY 3208136
N Dip : HEAVY CLAY 3208139
N Dip : WELDING ENGINEERING 3208140

EXAMINATION : 1 x 3 HOURS

S Y L L A B U S

1. Statics

Vectors, parallel forces, moments and couples. Co-planar vector systems. Conditions for static equilibrium. Vector notation

2. Centre of gravity

Square, disc, triangle, rectangle, cone, hemisphere, pyramid and composite bodies

3. Friction

The laws of solid friction; coefficient of friction; angle of friction; friction on an inclined plane

4. Simple lifting machines

Load effort, mechanical advantage, velocity ratio, efficiency. Law of machine. Pulley blocks, inclined plane, wedge, screw, wheel and axle, differential pulley, geared winch, levers. Reversibility

5. Dynamics. Basic problems only

   Linear and rotational motion; displacement, velocity and acceleration; motion with uniform acceleration; vertical motion under gravity. Newton's law

6. Momentum and impulse applied to practical problems such as jet reactions, flowing fluids, impact of jet on vanes etc.

7. Work, energy and power (linear and rotational)

   Diagram of work (uniformly varying force only), potential and kinetic energy; conservation of energy; power

8. Radial acceleration

   Acceleration due to change in direction; centripetal and centrifugal acceleration and force. Banking of tracks, vehicle on a flat road; overturning

9. Simple harmonic motion

   Periodic time, frequency, amplitude. Graphical representation of basic concepts. The simple pendulum

   Laboratory practicals should be indicated in the lecturer's guide

INSTRUCTIONAL OFFERING : DIGITAL SYSTEMS T2

CODE : 080800222

INSTRUCTIONAL PROGRAMME(S) : N Dip : ELECTRICAL ENGINEERING: HEAVY CURRENT 3208123
N Dip : ELECTRICAL ENGINEERING: LIGHT CURRENT 3208124
N Dip : METEOROLOGY 3222187
Gen Cert : MARITIME RADIO COMMUNICATION 3208968

EXAMINATION : 1 x 3 HOURS

S Y L L A B U S

1. Minimization of switching functions

   Selected minimization techniques including computer assisted techniques

2. Combinational logic circuits

   Arithmetic circuits: code converters; magnitude comparitors: parity circuits

3. Logic families and technology

   Characteristics and comparison of DL, RTL, TTL, MOS, CMOS, ECL, I^2L logic families: noise margin; wired AND/OR; tristate logic

4. Pulse circuits

   Electronic switches including diode, transistor and tunnel diode. Monostable, astable and bistable circuits; IC timers; Schmitt trigger; hysteresis curve of Schmitt trigger

5. Sequential logic circuits

   Modulus, asynchronous and synchronous counters; ring counters

INSTRUCTIONAL OFFERING : ELECTRICAL MACHINES T2

CODE : 080801322

INSTRUCTIONAL PROGRAMME(S) : N Dip : ELECTRICAL ENGINEERING: HEAVY CURRENT 3208123

EXAMINATION : 1 x 3 HOURS

S Y L L A B U S

Introduction: Requirements of ferro-magnetic, conducting and insulating materials used in machines, hysteresis and eddy current losses; laminating magnetic iron circuits subjected to pulsating and rotating fields; copper loss, friction and windage losses; basic cooling methods; types of enclosures and ventilation; types of bearings used

Medium and large machines must be considered with the construction of machines

1. Single-phase transformers

1.1 Single-phase transformers

Function of transformers; basic construction of core and shell types with concentric and sandwich windings; the emf equation, turns ratio and mmf balance i.e. approximate current and voltage ratio; resistance and leakage reactance; phasor diagram neglecting internal impedance volt drops, no-load current and its components; the approximate equivalent circuit, regulation and regulation phasor diagrams, load characteristics, effect of load pf; efficiency and losses; efficiency variation with load; influence of load pf; prediction of transformer performance, i.e. efficiency at different loads and pf's and regulation at different load pf's utilizing open and short circuit test results

1.2 Auto-transformers

Description and operation of tapped and continuously variable single-phase types; current in each section; saving of copper; advantages and disadvantages; applications

1.3 Instrument transformers

Reasons for their use instead of shunts and multipliers; current and potential transformers; theory, construction, applications and connections in circuit, ratio and phase angle, errors, testing

2. Induction machines

Construction of modern cage and slipring induction motors; simple concept of 3-phase multipolar windings; production of synchronously rotating field; n = f/p; principle of operation; slip and torque production; starting and running conditions; starting : direct-on-line; current surges; supply authority restrictions; starting current reduction using star/delta and auto-transformer starters (contactors); rotor resistor (wire wound and liquid); starting of slipring motors; protection and interlocking incorporated in starters

3. Direct current machines

3.1 Construction

Magnetic circuit: stator core and frame; poles; armature.
Electric circuit: shunt field; series and compound winding; interpole and armature windings; arrangement in slots; simple lap and wave windings; factors influencing choice

Commutator and brushes: principle of operation as a mechanical rectifier; brushes and brush gear; importance of brush grading, pressure, correct position and general maintenance of the commutator and brushes

Armature reaction: definition of; concept and effects to produce generator and motor action

Commutation: definition of; linear commutation; reactance emf; retarded commutation; sparking; functions of interpoles

The emf and torque equations applicable to motors and generators

3.2 Generators: Operation and load characteristics of separately excited, shunt, series and compound generators; applications of each type

3.3 Motors: Speed/torque or armature current (load) characteristics of shunt, series and compound motors; applications of different types

3.4 Starters: reasons for; starting and speed control of series motors using armature resistors (controller); starters used for small shunt and compound machines only, are uneconomical and outmoded since the advent of solid state variable armature voltage for starting

3.5 Speed control: field current control of shunt and compound machines; merits and disadvantages; effectiveness of armature voltage control for industrial processes; electro-magnetic (Ward-Leonard) control; main disadvantages; introduction to power electronics as a means of starting and control; fundamental principles; simple 1 phase systems

Electric braking: need for; dynamic, regenerative and counter current methods

INSTRUCTIONAL OFFERING : ELECTRONICS T2

CODE : 080802322

INSTRUCTIONAL PROGRAMME(S) : N Dip : ELECTRICAL ENGINEERING HEAVY CURRENT 3208123
N Dip : ELECTRICAL ENGINEERING LIGHT CURRENT 3208124
N Dip : METEOROLOGY 3222187
Gen Cert : MARITIME RADIO COMMUNICATION 3208968

EXAMINATION : 1 x 3 HOURS

S Y L L A B U S

1. Power supplies

Capacitor and inductor filters; voltage and ripple; efficiency of half and full wave rectification; peak diode current; zener diode; use in voltage regulation; emitter follower and darlington pair

2. Equivalent circuits

Parameters of general 4 terminal network; h-parameters; application of h-parameters; calculation of current, voltage and power gain; FET equivalent current generator; calculation of voltage and current gain

3. Amplifiers

Two and three stage R-C and transformer-coupled amplifiers; frequency response; power amplifier; class A, class B and AB push-pull amplifiers; complementary pairs

4. Feedback

Positive and negative feedback; types of feedback; effects of feedback; the emitter follower; decoupling; practical circuits

5. Waveform generators

Clipping and clamping; transistor oscillators; multivibrators; blocking oscillator; Schmitt trigger; generation of square, triangular and sawtooth waves

INSTRUCTIONAL OFFERING : ELECTRICAL ENGINEERING (H.C.) T2

CODE : 080800822

INSTRUCTIONAL PROGRAMME(S) : N Dip : ELECTRICAL ENGINEERING: HEAVY CURRENT 3208123

EXAMINATION : 1 x 3 HOURS

S Y L L A B U S

1. Single and three phase circuits

1.1 Single phase circuit

Concepts of admittance, conductance and susceptance; analysis of series, parallel and series-parallel (compound) circuits using the complex notation; resonance in series and parallel circuits at power frequencies

1.2 Three phase circuit

Phase and line voltage relationships as applied to 3-phase 3-wire and 3-phase 4-wire star and delta connected symmetrical sources; application of these systems (brief discussion); phase and line current relationships with balanced star and delta loads; line and neutral currents supplying 4-wire star connected loads; power and energy measurement; determination of power factor, kVAr and kVA for balanced loads using one and two wattmeters; summation of kVA of balanced loads of different power factors; power factor improvement by means of static capacitors

2. Complex waves

A periodic complex wave as the summation of harmonic components; series R, L and C loads connected to a complex supply; rms values; total power consumed; selective resonance

3. Alternating and direct voltage transmission

3.1 Direct voltage transmission

Typical single line diagrams from supply to consumer of two wire traction systems

3.2 Alternating voltage transmission

Typical single line diagrams from supply to consumer of 1-phase 2-wire and 3-phase 3-wire and 4-wire systems

3.3 Overhead lines

Stranded conductors; conductor materials; comparison of the properties of copper, cadmium copper, aluminium, steel-cored aluminium and copper weld steel; multi-bundle lines; dampers; supports; typical lattice steel, concrete and wood pole tower arrangements for single and double high voltage 3-phase lines, insulators; pin and suspension types, porcelain and glass, guard ring and arcing horns, testing of insulators; guard wires; joints; clamps; earthing; arrangement of lines for direct and alternating voltage traction. Performance of short lines (negligible capacitance); phasor and circuit diagrams; sending end voltage, current and pf, regulation; line copper loss and efficiency

3.4 Cables

Types of cables in use for 1-phase and 3-phase low and high voltage distribution systems

4. Rectification

Definition and purpose of uncontrolled and variable conversion; applications; 1-phase half and full-wave rectification; typical single and double-way multi-pulse transformer and rectifier circuits

4.1 Power rectification:

Principles, characteristics and applications of solid-state silicon diodes, thyristors, diacs and triacs; system protection. The steel tank mercury arc rectifier to serve as a brief introduction

4.2 Analytical treatment and performance:

Utility factor; interphase reactor; thyristor and triac triggering; voltage and current relationships; efficiency and regulation

5. Instrumentation

Construction, principle of operation and connection in circuit of power factor, frequency, 1-phase and 3-phase energy meters (3, 2 and single disc three phase units) and lux meters

INSTRUCTIONAL OFFERING : ELECTRICAL ENGINEERING (L.C.) T2

CODE : 080801122

INSTRUCTIONAL PROGRAMME(S) : N Dip : ELECTRICAL ENGINEERING: LIGHT CURRENT 3208124
Gen. Cert : MARITIME RADIO COMMUNICATION 3208968

EXAMINATION : 1 x 3 HOURS

S Y L L A B U S

1. Circuit theorems

Mesh current and node voltage analysis: Thevenin's and Norton's theorums; star to delta and delta to star transformations; super-position theorem; maximum power transfer

2. Resonance, harmonics, complex waves

Resonant circuits, series and parallel, selectivity, bandwidth, phase-frequency and amplitude-frequency plots; graphical addition of harmonics; symmetry of complex waves; current in R L C networks connected to complex wave voltage source; r.m.s. value of complex waves

3. Three-phase circuits

Star and delta connections; phase and line voltages and currents in balanced star and delta connected loads; apparent power; power factor; power factor improvement

4. Single-phase transformers

Principles of operation; e.m.f. equation; magnetic cores; magnetizing current waveform; resistance and leakage reactance; equivalent circuit; referred values; simple designs; open and short circuit tests; efficiency

5. A.C. and D.C. machines

Rotating magnetic fields; induction motors; torque; improvement of starting torque; d.c. machines; commutators; brushes; shunt and series motors

6. Measurements and measuring instruments

Power and power factor measurement; two wattmeter method for balanced three-phase loads; rotating disc induction type meter

INSTRUCTIONAL OFFERING : INDUSTRIAL INSTRUMENTS T2

CODE : 081500122

INSTRUCTIONAL PROGRAMME(S) : N Dip : ELECTRICAL ENGINEERING: LIGHT CURRENT 3208124

EXAMINATION : 1 x 3 HOURS

S Y L L A B U S

1. High and medium vacuum measurement

   McLeod gauge, ionization gauges, thermal gauges, diaphragm gauges, bellows gauges

2. Electronic pressure detectors and transmitters

   Strain gauge transducers, differential transformer type transmitters, inductance type transmitters, variable reluctance, capacitance, selecting a transducer

3. Measurement of flow rate and flow volume

   3.1 Differential pressure method: selection and installation of primary devices, flow calculations, throat diameter calculations

   3.2 Variable area flowmeters: theory and simple calculations

   3.3 Magnetic flowmeters

   3.4 Target meter, vortex meter, ultrasonic meter

   3.5 Open channel flow measurement

4. Measurement of level, depth and content

   Capacitance methods, conductance methods, rotating paddle, ultrasonic methods

5. Measurement of temperature

   Wheatstone bridge circuits, potentiometer circuits, quartz crystal thermometers, colour change, thermistors, radiation pyrometers

6. Transmitters and telemetering

   Pneumatic transmission, telemetering pneumatic transmission, signal converters, electronic transmission

7. Controllers and control elements

   Pneumatic controllers, control stations, integral desaturation, electronic controllers, control valves, control valve positioners and transducers

8. Laboratory work

INSTRUCTIONAL OFFERING : INDUSTRIAL TECHNOLOGY (L.C.) T2

CODE : 080804422

INSTRUCTIONAL PROGRAMME(S) : N Dip : ELECTRICAL ENGINEERING: HEAVY CURRENT 3208123
N Dip : ELECTRICAL ENGINEERING: LIGHT CURRENT 3208124

EXAMINATION : 1 x 3 HOURS

S Y L L A B U S

1. Component specification and testing

   Reading, understanding and obtaining necessary information from data sheets. Testing of components

2. P.C. board layout and design

   Design and layout rules for single and double sided p.c. boards; etching; through-hole plating

3. Quality control

   Simple statistics; sampling; MTBF and MTTR

4. Project

   A large project from schematic drawing to final working product including all relevant documentation. Fault finding techniques

INSTRUCTIONAL OFFERING : ENGINEERING MANAGEMENT T2

CODE : 040904222

INSTRUCTIONAL PROGRAMME(S) : N Dip : ELECTRICAL ENGINEERING : HEAVY CURRENT 3208123
N Dip : ELECTRICAL ENGINEERING : LIGHT CURRENT 3208124
N Dip : AIR CONDITIONING AND REFRIGERATION 3208126
N Dip : MECHANICAL ENGINEERING 3208129
N Dip : WELDING ENGINEERING 3208140

EXAMINATION : 1 x 3 HOURS

S Y L L A B U S

1. Introduction to management

2. Manufacturing management

3. Work study

4. Office administration

INSTRUCTIONAL OFFERING : STRENGTH OF MATERIALS T2

CODE : 081000122

INSTRUCTIONAL PROGRAMME(S) : N Dip : INDUSTRIAL ENGINEERING 3208120
N Dip : ELECTRICAL ENGINEERING: HEAVY CURRENT 3208123
N Dip : AIR CONDITIONING AND REFRIGERATION 3208126
N Dip : MARINE ENGINEERING 3208127
N Dip : MECHANICAL ENGINEERING 3208129
N Dip : WELDING ENGINEERING 3208140

EXAMINATION : 1 x 3 HOURS

S Y L L A B U S

1. Stress and strain

2. Thin cylinders subjected to internal pressure

3. Centrifugal stress in thin rotating cylinders

4. Shafts and rigid couplings

5. Helical springs

6. Pin jointed framed structures: Method of sections

7. Simply supported beams. Cantilevers

8. Testing of materials

   8.1 Testing and behaviour of steel, concrete and timber under test loads. Interpretation of results

   8.2 Testing machines to be used and/or discussed during these practical sessions

8.2.1 Tension

8.2.2 Compression

8.2.3 Shear

8.2.4 Hardness

8.2.5 Bend

8.2.6 Impact

8.2.7 Fatigue

INSTRUCTIONAL OFFERING : TELECOMMUNICATIONS T2

CODE : 080808122

INSTRUCTIONAL PROGRAMME(S) : N Dip : ELECTRICAL ENGINEERING: LIGHT CURRENT 3208124
Gen. Cert : MARITIME RADIO COMMUNICATION 3208968

EXAMINATION : 1 x 3 HOURS

SYLLABUS

1. Radio frequency spectrum and transmission

   Introduction to telecommunications; electromagnetic spectrum

2. Coupled circuits

   Mesh analysis of mutually inductive coupled circuits; double tuned circuits; bandwidth

3. Four terminal passive networks

   Attenuators; symmetrical and asymmetrical networks; T, bridged-T, lattice, pi networks; iterative and image impedances; image transfer coefficient; half sections; prototype high and low pass filters; characteristics and limitations; M-derived lowpass and highpass filters; characteristics; terminating half sections; composite filters

4. Transmission lines

   Infinite transmission line; phase change; signal delay; wavelength; velocity; finite line; primary and secondary constants; characteristic impedance; terminations; standing waves; SWR

5. Modulation

   Amplitude modulation; DSB, SSB, ISB; modulation index; power distribution; bandwidth; frequency modulation; NBFM, WBFM; modulation index; bandwidth; phase modulation; pulse modulation; PAM, PDM, PPM, PCM and delta modulation; quantization levels and noise; bandwidth

6. Electromagnetic waves, antenna, propagation

Electromagnetic waves; wave velocity; frequency; wavelength; polarisation; rays; wavefronts; propagation; ground and sky waves; skip; tropospheric scatter; ionosphere; MUF; fading; antenna; radiation pattern; field strength; effective height; gain; radiation resistance; feed lines; stub matching; dipoles; rhombic; broadside; collinear; stacked; Yagi-Uda; log periodic antennae

INSTRUCTIONAL OFFERING : DIGITAL SYSTEMS T3

CODE : 080800303

INSTRUCTIONAL PROGRAMME(S) : N Dip : ELECTRICAL ENGINEERING: HEAVY CURRENT 3208123
N Dip : ELECTRICAL ENGINEERING: LIGHT CURRENT 3208124

EXAMINATION : 1 x 3 HOURS

S Y L L A B U S

1. Displays and multiplexing

   LCD, LED and Nixie tube displays; display multiplexing; multiplexers and demultiplexers including reed switches

2. Registers and memories

   Memory registers; core storage; static and dynamic semiconductor memories; bubble memories; timing diagrams for memories

3. A/D and D/A conversion

   Weighted resistor and ladder D/A convertors; continuous balance, staircase, ramp, successive approximation, voltage to time, dual slope and voltage to frequency A/D converters; linearity; monotonicity; quantization error; resolution

4. Microcomputer hardware

   Typical microprocessor control units and their operation; I/O devices; interrupt systems; DMA; bit slicing; PROM programmers

5. Microcomputer software

   Microprocessor instruction sets; address modes; simple programs; function of a development system

INSTRUCTIONAL OFFERING : ELECTRICAL MACHINES T3

CODE : 080801403

INSTRUCTIONAL PROGRAMME(S) : N Dip : ELECTRICAL ENGINEERING: HEAVY CURRENT 3208123

EXAMINATION : 1 x 3 HOURS

SYLLABUS

1. Three-phase power transformers

1.1 Construction

Construction of core, shell and five-limb transformers; commercial requirements of insulating materials; methods and classes of cooling; purpose and properties of transformer oil

1.2 Theory of performance

Referred, equivalent and per unit (percentage) values; predicting performance using the equivalent circuit; regulation and efficiency; magnetic circuit calculations

1.3 Connections

Polarising and phasing out; standard transformer connections; the Scott connection; auto-transformers; merits and disadvantages of different type of connections; fundamentals of tap-changing; tertiary windings

1.4 Harmonics

Generation of harmonic voltages and currents in core, shell and 5 limb transformers with different types of connections; harmonic suppression

1.5 Parallel operation

Essential and desirable requirements for successful parallel operation; load sharing with equal and unequal voltage ratios and percentage impedances

1.6 Testing:

1.6.1 Open-circuit and short-circuit

1.6.2 back-to-back, and

1.6.3 delta-open-delta tests for predicting efficiency, regulation and temperature rise; short time temperature tests

1.7 Reactor and magnetic amplifier

Methods of construction and principle of operation of the saturable reactor and magnetic amplifier; applications

2. Direct current machines

2.1 Construction

A more detailed review of modern constructional and design methods e.g. epoxy encapsulation, synthetic binders, vent ducts forced cooling with heat exchangers; classes of insulating materials etc.

2.2 Armature windings

Double layer multi-coils; arrangement in slots; simplex lap and wave connections, coil span, commutator and winding pitch, main factors influencing choice of winding and number of slots, limitations imposed on type of winding by the number of commutator segments (coils) and number of slots, dummy coils

2.3 Armature reaction

Mmf and flux density distribution curves; concept of direct and quadrature mmf axes; effect of armature reaction mmf upon the operation of a dc machine; emf between adjacent commutator segments, commutator flashover, construction and design methods used to overcome the undesirable effects produced by armature reaction, compensating windings

2.4 Commutation

Cause and effects of retarded and accelerated commutation, current distribution under brush, linear and sinusoidal commutation using commutating poles and high contact resistance brushes; interpole strength determination and adjustment

2.5 Performance

Motor speed control using variable armature voltage solid state sources, more in depth treatment, comparison and application of multi-pulse thyristor systems, power loss, efficiency; temperature rise; duty and rating

2.6 Testing

Direct load and acceptance tests, short-time rated, blackband back to back and field 'kick' tests; armature winding fault location

2.7 The quadrature-field generator

Methods of construction and principle of operation of the constant current generator and rotating amplifier; applications

2.8 Electromagnets

Function and construction; applications such as lifting, sorting, clutches, contactors, etc, magnetic circuit and basic design calculations

3. Induction machines

Speed/torque characteristics; starting, stalling and normal torque, effect of rotor circuit resistance; torque equation; power transfer line diagram; analysis and prediction of performance using the 'exact' and approximate equivalent circuit, the no-load, locked rotor tests and circle diagram; speed control using rotor resistance and pole amplitude modulation; abnormal operation; electric braking; general comparison of cage and slipring machines; design parameter variation to suit different applications, the 3-phase induction regulator; self and separately excited induction regulator; single phase series motors, construction, operation and application of the different types

4. Synchronous machines

4.1 Construction

4.1.1 Basic methods of construction of low and high speed machines; cooling; methods of excitation

4.1.2 Armature windings: Single and double layer windings; generation and suppression of harmonic emfs; distribution and chording; eddy currents; emf and torque equations

4.1.3 Armature reaction: Mmf distribution curves, direct and quadratic components

INSTRUCTIONAL OFFERING : ELECTRONIC MEASUREMENTS T3

CODE : 080802003

INSTRUCTIONAL PROGRAMME(S) : N Dip : ELECTRICAL ENGINEERING: LIGHT CURRENT 3208124

EXAMINATION : 1 x 3 HOURS

SYLLABUS

1. Standards and units
2. Measurement and accuracy
3. Generators
4. Comparison methods of measurement
5. Measuring devices
6. Oscilloscope
7. General measuring techniques
8. Transducers

INSTRUCTIONAL OFFERING : ELECTRONICS T3

CODE : 080802403

INSTRUCTIONAL PROGRAMME(S) : N Dip : ELECTRICAL ENGINEERING: HEAVY CURRENT 3208123
N Dip : ELECTRICAL ENGINEERING: LIGHT CURRENT 3208124

EXAMINATION : 1 x 3 HOURS

S Y L L A B U S

1. Power supplies

   Voltage and current regulated supplies; over voltage and over current limiting and protection; switching mode regulators; converters; inverters

2. Amplifiers

   D.C. amplifiers; complementary emitter follower; differential amplifier; cascade amplifier; chopper stabilization; the real op-amp; applications of op-amps; r.f. and video amplifiers

3. Linear integrated circuits

   Phase locked loops; timers; analog multipliers; waveform generators

4. Oscillators

   Positive feedback and negative resistance; Barkhauser criteria; phase shift oscillator; Wien bridge oscillator; tuned oscillators; Hartley and Colpitts oscillators; Xtal oscillators; stability criteria

5. Filters

   Properties of passive filters; active filters (simple and Butterworth)

6. Noise

Noise sources e.g. thermal, transistor; noise/frequency relationships; signal-to-noise ratio; noise figure; noise measurement; low noise amplifiers

7. Pulse electronics

Diode switches; CMOS switches; sample-and-hold circuits; D/A and A/D conversion

INSTRUCTIONAL OFFERING : ELECTRICAL ENGINEERING (H.C.) T3

CODE : 080800903

INSTRUCTIONAL PROGRAMME(S) : N Dip : ELECTRICAL ENGINEERING: HEAVY CURRENT 3208123

EXAMINATION : 1 x 3 HOURS

SYLLABUS

1. Asymmetrical three phase circuits

   Analysis unbalanced star and delta loads supplied from 3 and 4-wire symmetrical supply systems. Measurement of power and energy using 3 wattmeters, the two-wattmeter and single wattmeter (double switching method) for measuring power and kVAr. Concept and definition of symmetrical components, resolution of any set of 3-phase voltages or currents; resolution of line quantities into the symmetrical components; symmetrical components of impedance of 3-phase loads; symmetrical components of powers; asymmetrical 3-phase voltages applied to balanced loads

2. Alternating voltage transmission

   2.1 Overhead lines

   2.1.1 Line diagrams of typical 3-phase systems (primary, secondary and distribution); line resistance; inductance and capacitance of 1-phase and 3-phase lines, symmetrical line spacing; transposition of lines; electric stress; corona discharge; electric field distribution with single and string insulators

   2.1.2 Performance: Analysis of long lines; nominal T and π methods; phasor and circuit diagrams; sending end voltage, current and pf; regulation; line copper loss and efficiency; corona discharge power loss; disruptive and visual critical voltages; tension and sag with the same tower levels using the parabolic (approximate) method; effect of wind and ice loading

   2.2 Underground cables

   Performance: Breakdown voltage, maximum power capacity, thermal loading, insulation resistance, capacitance, insulation grading,

...

inductance, skin effect, loss angle, dielectric hysteresis loss and leakage current loss, maximum electric stress, capacitance of 3-core belted cable

3. Switchgear

Purpose of switchgear and links; features, construction and operation of alternating and direct voltage air blast and oil circuit breakers; principles of arc suppression; isolating switches; fuse gear; construction, operation and rating of HRC fuses; oscillogram analysis; prevention of single phasing

4. Inversion

Principles of inverted operation using thyristors; commutation requirements; typical connection diagrams; use of direct voltage links

5. Urban and rural systems

Primary distribution; main substation; types of feeders for rural and urban areas; parallel or ring main feeders; typical voltages; secondary distribution; the standard low voltage sup ly system; taps off the system; radial or ring distributors; limitation of supply area by excessive voltage drops

6. Illumination

Lamps: incandescent, halogen and high and low pressure discharge types (fluorescent, mercury and sodium vapour); characteristics and efficiencies; basic construction; typical starting circuits; colour characteristics and correction; stroboscopic effects and remedies. Inverse square and cosine laws of illuminance based on "point" source; modification due to use of linear source; basic design for illuminance of interior working surface using these laws; glare and its effect as a parameter in lighting design

INSTRUCTIONAL OFFERING : ILLUMINATION ENGINEERING T3

CODE : 080804103

INSTRUCTIONAL PROGRAMME(S) : N Dip : ELECTRICAL ENGINEERING: HEAVY CURRENT 3208123

EXAMINATION : 1 x 3 HOURS

S Y L L A B U S

1. The eye and vision

1.1 Structure of the human eye: action of main parts. Accommodation and convergence. Rod and cone elements of retina: elementary theory of sight

1.2 Sensitivity to light intensity and colour. Relative luminous efficiency curves: Purkinje effect. Threshold of vision. Relation between stimulus and sensation: Weber's law and Fechner's fraction

1.3 Phenomena of vision: elementary study of adaptation, persistence of vision, glare (disability and discomfort), fatigue of retina, visual acuity and contrast

1.4 Elementary colour vision: additive and subtractive colour mixture. Colour of light (special hue and saturation) and colour rendering properties

2. Radiation and light production

2.1 Radiation: wavelength and frequency. The spectrum. Dispersion. Principle of prism and grating spectrometers. Spectra of common light sources: spectral distribution curves. Polarization and polarizing materials

2.2 Photo-electric effects: principles and usual forms of photoelectric cells. Fluorescence, electroluminescence, liquid crystals and phosphorescence: excitation and emission bands: Stoke's Law

2.3 Radiation from a hot body: dependence of radiation on temperature. Total radiator (black body): characteristics of spectral energy distribution curves

2.4 Electric discharge in a gas. Effect of gas pressure and current density: form of discharge at low pressure. Volt-ampere characteristics. Current limitations

3. Photometric theory

3.1 Photometric concepts, units and definitions. Primary standard of light. Relation between flux, intensity, illuminance and luminance. Inverse square and cosine laws of illuminance. Symmetric and asymmetric light distributions. Polar curves and isocandela diagrams. Light flux calculations; zone factors. Russell angles and Rousseau diagram. Light distribution and total flux for uniform diffusing spherical, cylindrical and plane sources

3.2 Illuminance calculations: elementary comparison of point, infinite line and surface sources. Isophot (iso-illuminance) curves, and their use to calculate light flux on an area. Diversity ratio

3.3 Colour specification: colour temperature. Principles of trichromatic method of specification and colorimetry. Introduction to C.I.E. system and chromaticity diagram

4. Photometry

4.1 Photometric method: principles of visual and of photo-electric photometry. Sub-standards of intensity and flux. Sources of error

4.2 Essentials of the photometric bench and auxiliary equipment. Lummer-Brodhun photometer head and prism cubes (equality of luminance and contrast patterns). Simple photo-cell circuits used in photometry

4.3 Intensity distribution photometers: principles, calibration and use of typical forms. Spherical integrating (flux) photometer: elementary theory, essential features of construction and use

4.4 Illuminance photometers (visual and photo-electric): principles, calibration and use of typical instruments. Measurement of luminance, using illuminance photometer

5. Light sources

5.1 Daylight. Spectral characteristics of daylight (sky and sunlight). Variability of level with time of day and year and with weather conditions. Conventional minimum daylight illuminance

5.2 Electric filament lamps. Choice of filament materials. Vacuum and gas filling, coiling of filament. Approximate filament temperatures and efficiencies. Lamp characteristics with variations of applied voltage. Common types of lamp: general construction and essential features. Effect of filament form and bulb finish on light distribution

5.3 Electric discharge lamps. Negative flow and positive column tubes. Cold and hot cathodes. Usual gases and vapours: use of fluorescence. Essential features of construction, usual operating circuits, approximate efficiency and characteristics of modern sodium vapour lamps, and high and low presure mercury vapour lamps

6. Light control and lighting materials

6.1 Reflection: nature and laws of specular and diffuse (uniform and preferential) forms. Reflection factor; selective reflection. Optics of spherical mirrors

6.2 Refraction: definitions and laws. Critical angle and total reflection. Refraction and reflection by a prism. Optics of thin lenses

6.3 Transmission: neutral and selective forms, and effect of thickness. Transmission and absorption factors

6.4 Materials used for reflectors: their reflection factors and general properties. Characteristics of specular reflectors of plane, spherical, elliptic and parabolic form. Common types of reflector (diffusing and specular), and their light distribution

6.5 Practical use of refracting and reflecting prisms. Usual forms of refractors and suitable materials

6.6 Types and properties of diffusing glasses and plastics, and their action on light rays. Common forms of diffusing luminaires; dependence of light distribution on shape of diffuser

7. Applied lighting

7.1 Factors affecting lighting requirements - quantity and quality (including human reaction). Simple task analysis

7.2 Daylighting of interiors: factors affecting amount of daylight in a room. Daylight factor and sky factor: principles of methods of determination

7.3 Daylight contours. Conventional minimum daylight factors; no-sky line. Rules for provision of good daylighting indoors. Use of supplementary, artificial light

7.4 The principles of good lighting for interiors, as given in the I.E.S. and S.A.B.S. codes. Basis of determining illuminance requirements, and assessing direct glare from lighting fittings: general levels recommended for normal tasks. Installation planning: general and local lighting. Classification of lighting luminance by upward and downward flux components. Coefficient of utilization and factors affecting it. Simple calculations of illuminance and power required: lumen method of design. Maintenance. Elementary study of interior lighting of homes, factories, offices and shops

7.5 The general principles of street lighting with reference to the relevant B.S. and S.A.B.S. Code of practice. Road surface reflection characteristics. Usual types of light distribution from lanterns, and of installation system and arrangement; effect of variation of fundamental dimensions, spacing, mounting height; effective width and overhang. Group classification of installations: broad requirements for each group

7.6 Exterior lighting; flood lighting; security lighting; sports lighting

8. Energy supply and costs

An elementary knowledge of the principles of the following:

8.1 Electric power distribution systems: wiring, switching, and protective apparatus

8.2 Cost of lighting: factors affecting costs, capital and running costs. Tariff schemes. Simple calculations of costs

INSTRUCTIONAL OFFERING : INDUSTRIAL ELECTRONICS T3

CODE : 080804203

INSTRUCTIONAL PROGRAMME(S) : N Dip : ELECTRICAL ENGINEERING: HEAVY CURRENT 3208123
N Dip : ELECTRICAL ENGINEERING: LIGHT CURRENT 3208124

EXAMINATION : 1 x 3 HOURS

S Y L L A B U S

1. Transducers

   Transfer function: error; response; cross-sensitivity: construction, characteristics and applications of potentiometers, LVDTs thermistors, thermocouples, strain gauges, flowmeters, tachometers, radiation detectors, level detectors

2. Power control

   Thyristor; triac; diac; UJT triggering; control loops; control techniques; flywheel diode; braking techniques; phase control, chopper control, d.c. link and cycloconvertors

3. Heating

   Induction and dielectric heating; the magnetron

4. Welding

   Resistance welding; energy storage welding; weld control; sequence timers; ignitrons; electron beam welding; plasma welding; laser welding

5. Electronic weighing

   Load cells; static and dynamic weighing; readout systems

6. Ultrasonics

Generation; magnetostriction; piezoelectric transducers; transmission; doppler effect; flaw detection; thickness guaging; fluid flow measurements; cavitation; drilling; soldering; welding; sterilising

7. X-rays and radiation equipment

X-ray production; radioactive sources; X-ray detection; radiation measuring equipment; applications

8. Telemetry

Communication channels; multiplexing; sampling theorom; redundancy; encoding techniques; parity checks; systems; data logging

9. Numerical control

Part programming; co-ordinate positioning; contouring control

INSTRUCTIONAL OFFERING : INDUSTRIAL INSTRUMENTS T3

CODE : 081500203

INSTRUCTIONAL PROGRAMME(S) : N Dip : ELECTRICAL ENGINEERING: LIGHT CURRENT 3208124

EXAMINATION : 1 x 3 HOURS

S Y L L A B U S

1. Measurement and control of pressure

   1.1 Characteristics of pressure

   1.2 Control systems, self-operated pressure controllers, general pressure control system, proportional pressure control, application considerations, control of typical processes

2. Measurement and control of flow

   2.1 Characteristics of flow control systems

   2.2 Installation of primary device, problems caused by pumps, control of flow between two sources of pressure, selection of valve flow characteristics, control of typical processes

3. Measurement and control of temperature

   3.1 Characteristics of temperature control systems

   3.2 Techniques to improve control, control of typical processes

4. Measurement with radioactive sources

   Radioactivity, radioactive decay, radio-isotopes, physical properties of radiation, radiation detectors, radio-isotope measurements, safety, instrumentation, regulatory control

5. Process control and computers

   Analogue interface equipment, handling of signals, closed loop control, general process computer systems, system response time, types of process computers, choosing the correct computer

6. Analyzers

Gas density, viscosity, humidity and moisture, vibration, mass, pH thermal conductivity, oxygen analyzers, ultra-violet, chromatographs, infrared

7. Explosion hazards and intrinsic safety

Definitions for hazardous locations, protection methods, advantages and disadvantages of methods, pressurization, explosion-proof components, intrinsic safety, energy levels, evaluating intrinsic safety of a loop

8. Laboratory work

INSTRUCTIONAL OFFERING : ENGINEERING MANAGEMENT T3

CODE : 040904303

INSTRUCTIONAL PROGRAMME(S) : N Dip : ELECTRICAL ENGINEERING : HEAVY CURRENT 3208123
N Dip : ELECTRICAL ENGINEERING : LIGHT CURRENT 3208124
N Dip : MECHANICAL ENGINEERING 3208129
N H Dip : AIR CONDITIONING AND REFRIGERATION 3508229

EXAMINATION : 1.x 3 HOURS

S Y L L A B U S

1. Industrial legislation

2. The personnel function
   - 2.1 Human nature
   - 2.2 Man in business organisation
   - 2.3 Manpower planning
   - 2.4 Training and development of new workers
   - 2.5 Job evaluation, job description and job specification
   - 2.6 Merit rating, promotion and interviews
   - 2.7 Health and safety
   - 2.8 Welfare
   - 2.9 Job satisfaction
   - 2.10 Labour turnover

INSTRUCTIONAL OFFERING : AUTOMATIC CONTROL T3

CODE : 080805903

INSTRUCTIONAL PROGRAMME(S) : N Dip : ELECTRICAL ENGINEERING: HEAVY CURRENT 3208123
N Dip : ELECTRICAL ENGINEERING: LIGHT CURRENT 3208124

EXAMINATION : 1 x 3 HOURS

S Y L L A B U S

1. Mathematical description of system components

2. Transient response of systems

3. Frequency response of systems

4. Accuracy and stability of feedback systems

5. Root locus

6. Design of closed loop systems

INSTRUCTIONAL OFFERING : RADIO ENGINEERING T3

CODE : 080807103

INSTRUCTIONAL PROGRAMME(S) : N Dip : ELECTRICAL ENGINEERING: LIGHT CURRENT 3208124

EXAMINATION : 1 x 3 HOURS

S Y L L A B U S

1. Radio frequency amplifiers

   Class A, B, and C r.f. amplifiers - valve and transistor - angle of flow - power relationships - effect of loading; Class A broadban VHF amplifier; anode and collector-modulated Class C tuned amplifier

2. Frequency synthesis

   Phase locked loops; digital division; time constance of PLL's; phase noise - per Hz representation

3. Amplitude modulation and demodulation

   Amplitude modulation; double sideband suppressed carrier: demodulation of DSB-SC signals; pilot carrier system; double sideband large carrier; carrier and sideband power in AM; generator and demodulation of DSB-LC (AM) signals; square law modulator; piecewise-linear modulator; SSB modulation and balanced modulators; envelope demodulation; synchronous detection; vestigial sideband modulation

4. Frequency modulation and demodulation

   Angle modulation; FM & PM: wideband FM; general approximations - Woodwards theorem; FM with sinusoidal modulation; Bessel functions; Carsons rule; pre-emphasis; average power in angle-modulated waveforms; generation of wideband FM; demodulation of FM signals

5. Superheterodyne receiver

   Active and passive double balanced mixers; compression; input and output matching of mixers; conversion noise; switching non-linearities; cascade amplifiers using junction transistors and F.E.T.'s; helical filters; integrated i.f. amplifiers; crystal filters; envelope; coherent detection; stagger tunes; PLL; pulse counting discriminators; crystal oscillators and VFO's; tracking; step recovery diode harmonic generator; AGC, AFC; image rejection; images rejection mixers; SSB reception

6. Antennae

Array theory; Yagis; input impedance of driven element; impedance transformation by unsymmetrical element; diameter in folded dipole; linear antennae; travelling wave antennae; the small loop antenna; the helical beam antenna; frequency independent antennae; self and mutual impedance arrays of dipoles; reflector and lens antennae; slot and complementary antennae; horn antennae; active antennae

INSTRUCTIONAL OFFERING : STRENGTH OF MATERIALS T3

CODE : 081000203

INSTRUCTIONAL PROGRAMME(S) : N Dip : ELECTRICAL ENGINEERING: HEAVY CURRENT 3208123
N Dip : MARINE ENGINEERING 3208127
N Dip : MECHANICAL ENGINEERING 3208129
N Dip : WELDING ENGINEERING 3208140

EXAMINATION : 1 x 3 HOURS

S Y L L A B U S

1. Temperature stress and restricted expansion in simple and compound bars

2. Properties of beam sections. Centroids, area moments of inertia and section moduli radii of gyration of different sections including built-up sections. Use of section tables

3. Bending moments and shear forces

   More advanced problems including built-in beams with central point load and uniformly distributed load throughout its length

4. The theory of bending

   Calculations of bending stress for plain and built-up sections used for cantilevers, simply supported beams and built-in beams

5. Fatigue

   Fatigue strength and endurance limit. Endurance limit modifying factors, surface finish etc. Stress pattern factors

6. Short columns and struts

   Direct and eccentric loading

7. Pin-jointed and simple framed structures

Practical applications, shear legs, jibs, travelling cranes, pylons etc.

8. Ropes, chains and attachments

Strength and testing attachments for lifting gear

9. Catenaries

Sag and tension of wires, ropes and chains

10. Reinforced concrete

A basic knowledge of the purpose and design of steel reinforcement of concrete beams, slabs and columns

11. Foundations

Methods of testing bearing pressures of ground (outline treatment only)

12. Strain energy, applied to gradually and suddenly applied loads including impulsive loads

INSTRUCTIONAL OFFERING : TELEVISION T3

CODE : 080808703

INSTRUCTIONAL PROGRAMME(S) : N Dip : ELECTRICAL ENGINEERING: LIGHT CURRENT 3208124

EXAMINATION : 1 x 3 HOURS

S Y L L A B U S

1. Colorimetry

   Visible spectrum: inverse square law; illumination; neutral density filter; 3 colour theory; colour mixing; photopic curve; Grassman's Law; trimtimulus values, chromaticity diagram, illuminants; black body locus; colour temperature

2. Television receiver fundamentals

   Scanning; interlace; aspect ratio; synchronization; equilization; the video signal; picture/sync ratio, resolution; bandwidth; the CCIR system I

3. Generation of television signals

   Telecine; vidicon; plumbicon; gamma correction; solid state image sensor; lenses; lighting units and techniques for television; pattern generator; character generation and electronic games

4. Studio systems

   Sync pulse generator; distribution amplifiers; vision switching; special effects; genlock and slavelock; small monochrome studio organisation

5. Antennae and distribution systems

   Yagi-Uda and log periodic antennae; the balun; antenna amplifiers; distribution systems; signal propagation; multipath propagation

6. Receivers and monitors

Picture tubes; electron gun assembly; phosphors; aluminium backing; deflection yokes; beam centering; pincushion distortion; gamma; characteristic curves; plasma and liquid Xtal display devices; block diagram of monochrome receiver; selected circuits

7. Measurements

IF response; linear and non-linear distortion; sine squared pulse and bar technique

INSTRUCTIONAL OFFERING : DIGITAL SYSTEMS T4

CODE : 080800406

INSTRUCTIONAL PROGRAMME(S) : N H Dip : ELECTRICAL ENGINEERING: HEAVY CURRENT 3508225
N H Dip : ELECTRICAL ENGINEERING: LIGHT CURRENT 3508226

EXAMINATION : 1 x 3 HOURS

SYLLABUS

1. Alternative approaches to logic design

   Combinational and sequential designs using MSI and LSI, ROM, ROM with feedback. ROM pairs, ROM pairs with flipflops, PLAs, microprocessors

2. Digital interface techniques

   Interconnection of non-compatable equipments: IEEE 488 bus, CCITT V24 and serial interfaces

3. Data transmission and networks

   Channels; cables; data networks; synchronous and asynchronous transmission; line protocols; packet switching; SAPONET

4. Software engineering

   User programs and languages; translators; operating systems; realtime, multiprogramming, time sharing systems; life cycle of a program; top-down and bottom-up techniques; structured programming

INSTRUCTIONAL OFFERING : ELECTRICAL MACHINES T4

CODE : 080801506

INSTRUCTIONAL PROGRAMME(S) : N H Dip : ELECTRICAL ENGINEERING: HEAVY CURRENT 3508225

EXAMINATION : 1 x 3 HOURS

S Y L L A B U S

1. Synchronous machines

1.1 Operation of the alternating current generator

Effect of armature reaction upon the performance of an isolated machine; influence of load power factor; load characteristics; regulation; concept of synchronous impedance in cylindrical rotor machines; two-reaction theory as applied to salient pole machines; emf and mmf phasor diagrams; open and short circuit tests; methods for predicting regulation; synchronising and parallel operation of alternators; the effect of 1-phase and 3-phase symmetrical short circuits and high voltage surges

1.2 Operation of synchronous machines connected to large supply systems

Concept of infinite busbars; the synchronous machine as motor or generator; synchronising power and torque; hunting; effect of excitation and power input variation upon the performance of an alternator; behaviour of a synchronous motor with changes in excitation and mechanical loading; V curves; phase compensator; the load diagram

1.3 Synchronous induction motor

Construction and operation, performance characteristics and applications

2. Principles of design

Philosophy and elements of design; main factors; computer-aided design; specific electric and magnetic loadings; influence of diameter, tooth taper, iron losses, magnetising current slot loading; airgap output equation of ac and dc machines; peripheral speed and cooling; losses and rating; fundamentals of transformer design

3. Induction motor performance

3.1 Speed control: static variable frequency schemes for speed control of cage motors; dynamic and electronic method for slip power recovery and speed control of slipring motors

3.2 Pf adjustment: reasons for static capacitors; synchronous induction motor

4. Special machines

Basic construction, principle of operation and application of alternating voltage series commutator, shaded pole, reluctance and hysteresis motors; power selsyns; stepper motors and linear machines

INSTRUCTIONAL OFFERING : ELECTRONIC MEASUREMENTS T4

CODE : 080809906

INSTRUCTIONAL PROGRAMME(S) : N H Dip : ELECTRICAL ENGINEERING: LIGHT CURRENT 3508226

EXAMINATION : 1 x 3 HOURS

S Y L L A B U S

1. Statistical analysis
2. Generators
3. Hign frequency measurements
4. Measuring instruments
5. Scientific measuring equipment

   or

6. Communications measurements
7. Measuring techniques
8. Applications

INSTRUCTIONAL OFFERING	:	ELECTRICAL ENGINEERING (H.C.) T4
CODE	:	080801006
INSTRUCTIONAL PROGRAMME(S)	:	N H Dip : ELECTRICAL ENGINEERING: HEAVY CURRENT 3508225
EXAMINATION	:	1 x 3 HOURS

S Y L L A B U S

1. Protection

   Types of faults; causes of faults; aims of protection; requirements of a protective system; elements used in protective systems; types of protective systems; systems comparison; protection of large 3-phase transformers and alternators; protection of busbars and ring mains; protection of lines against surges; symmetrical and asymmetrical short circuit fault calculations; maintenance of protection equipment; fault location

2. Interconnected grid system of transmission

   Interconnectors; calculations of currents in interconnected systems; factors determining the power supply from point to point; control of power flow; voltage regulation; accommodation of voltage drop; on-load tap changing interconnector transformers, induction regulator, series boosting transformers and synchronous phase modifiers; calculations involving the latter units; power transmitted/angle diagrams for lines with equal voltages at both ends; stability of operation of synchronous systems; steady state stability, transient stability, the swing equation, equal area criterion of stability, step by step solution of the swing curve

3. Illumination

   Desirable optical, electrical, mechanical and thermal properties of luminaires; typical industrial and commercial types; basic function of luminaire; polar and iso-illuminance curves in lighting design. Simple floodlighting of exterior surface; effect of surface reflectance, absorption and colour in modifying treatment as applied to indoor lighting; security lighting and factors involved in approach to system design

4. Economics

The economics of power systems; principles, economics of generation; transmission and distribution; equipment; purchasing and contract procedure; revenue

INSTRUCTIONAL OFFERING : ELECTRONIC DESIGN T4

CODE : 080802106

INSTRUCTIONAL PROGRAMME(S) : N H Dip : ELECTRICAL ENGINEERING: HEAVY CURRENT 3508225
N H Dip : ELECTRICAL ENGINEERING: LIGHT CURRENT 3508226

EXAMINATION : 1 x 3 HOURS

SYLLABUS

1. Specifications

   Reading and understanding the specifications of electronic circuits and systems

2. Feasibility study

   Literature survey; alternative design options

3. Costing

   Material costing; labour costing; trade-offs between specifications and cost, maintainability and cost, etc.

4. Breadboarding

   Techniques and limitations

5. Construction

   Design, layout and construction techniques

6. Packaging

   Costing of enclosures; choice of enclosure in adverse environments; ergonomic layout considerations

7. Documentation

Technical reports, manuals, faultfinding trees, etc.

All the above to be reinforced with case studies, design studies and practical projects

An "open book" examination is essential

INSTRUCTIONAL OFFERING : AUTOMATIC CONTROL T4

CODE : 080806006

INSTRUCTIONAL PROGRAMME(S) : N H Dip : ELECTRICAL ENGINEERING: HEAVY CURRENT 3508225
N H Dip : ELECTRICAL ENGINEERING: LIGHT CURRENT 3508226
N H Dip : AERONAUTICS 3508322

EXAMINATION : 1 x 3 HOURS

S Y L L A B U S

1. Analogue computers and system simulation

2. State space representation and analysis

3. Digital control

4. Control components and systems

5. Introduction to design

6. Parameter optimization

7. Non-linear systems

INSTRUCTIONAL OFFERING : STRENGTH OF MATERIALS T4

CODE : 081000306

INSTRUCTIONAL PROGRAMME(S) : N H Dip : ELECTRICAL ENGINEERING: HEAVY CURRENT 3508225
N H Dip : MECHANICAL ENGINEERING 3508230
N H Dip : WELDING ENGINEERING 3508239

EXAMINATION : 1 x 3 HOURS

SYLLABUS

1. Complex stress and strain, principal stresses and planes. Mohr's circle for stress and strain. Three dimensional strains. Relationship between the elastic constants

2. Measurement of stress and strain

   2.1 A general background of the electronic apparatus for measuring strain as well as the technique in the application of the various types of gauges

   2.2 The use of brittle lacquers and photo-elastic methods of assessing the positions of possible high stress areas before applying strain gauges

   2.3 When the strains have been measured, the method of calculating principal strains and stresses is to be included

3. Combined bending and twisting of shafts

4. Slope and deflection of beams

   Cantilevers, simply supported and built-in beams. Combinations of direct, uniformly distributed loads including props. Use of integration and moment-area methods. Leaf springs

5. Struts

   Simple and built-up struts, effects of different end fastenings, central loading only. Use of recognised formulae

6. Simple and compound thick cylinders

   Stresses and strains resulting from internal and external pressures, shrink fits

7. Non-uniform sections

   Loading of tapered sections and spherical balls, tension and compression only

APPENDIX 6

TEXT ANALYSIS :- RAW DATA

TABLE:-ON THE THEORY NEED PER INSTRUCTIONAL
OFFERING PER YEAR WITH REFERENCE
TO TEXT CHAPTER AND PAGE.

MATHS	SUBJECT	YEAR	TEXT	CHAPT.	PAGES
1	TEF3	3	44	9	287-290
1	TEF3	3	44	9	295-300
1	TEF3	3	44	9	300-302
1	TEF3	3	44	9	302-305
1	TEF3	3	44	9	306-308
1	TEF3	3	44	9	290-294
1	TEF3	3	43	6	206-209
1	TEF3	3	43	8	237-245
1	TEF3	3	43	9	255-263
1	TEF3	3	44	14	488-501
1	TEF3	3	43	3	90-91
1	TEF3	3	44	13	439-442
1	TEF3	3	44	13	443-450
1	TEF3	3	44	13	445-450
1	TEF3	3	44	13	450-454
1	TEF3	3	44	13	459-462
1	TEF3	3	44	13	462-470
1	TEF3	3	44	13	472-474
1	TEK4	4	18	2	38-55
1	TEK4	4	18	7	164-171
1	TEK4	4	18	7	184-190
1	TEK4	4	18	8	212-217
1	TEK4	4	18	8	217-220
1	TEK4	4	50	5	92-96
1	TEK4	4	50	33	543-545
1	TIC2	2	36	7	17-32
1	TEH3	3	11	1	4-6
1	TEH3	3	11	1	6-10
1	TEH3	3	11	1	16-17
1	TIA3	3	50	3	47-49
1	TIA3	3	50	22	405-410
1	TIA3	3	50	22	410-411
1	TTC4	4	38	8	84-98
1	TTC4	4	38	B	247-248
1	TEF2	2	43	2	26-34
1	TEF2	2	43	8	280-282
1	TEF2	2	42	1	3,4,47
1	TEF2	2	42	10	252-254
1	TEF2	2	42	3	70-79
1	TRB3	3	41	10	320-329
1	TRB3	3	41	7	227-246
1	TTB2	2	41	10	319-329
1	TTB2	2	33	5	76-80
1	TTB2	2	33	6	90-94
1	TEF2	2	58	6	172-179
1	TEF2	2	58	8	230-232
1	TEH3	3	56	19	412-425
1	TIB3	3	68	11	500-502
1	TIB3	3	68	11	471-475

TABLE:-ON THE THEORY NEED PER INSTRUCTIONAL OFFERING PER YEAR WITH REFERENCE TO TEXT CHAPTER AND PAGE.

MATHS	SUBJECT	YEAR	TEXT	CHAPT.	PAGES
1	TIB3	3	69	14	595-597
1	TEF3	3	44	9	287-290
1	TEF3	3	44	9	295-300
1	TEF3	3	44	9	300-302
1	TEF3	3	44	9	302-305
1	TEF3	3	44	9	306-308
1	TEF3	3	44	9	290-294
1	TEF3	3	43	6	206-209
1	TEF3	3	43	8	237-245
1	TEF3	3	43	9	255-263
1	TEF3	3	44	14	488-501
1	TEF3	3	43	3	90-91
1	TEF3	3	44	13	439-442
1	TEF3	3	44	13	443-450
1	TEF3	3	44	13	445-450
1	TEF3	3	44	13	450-454
1	TEF3	3	44	13	459-462
1	TEF3	3	44	13	462-470
1	TEF3	3	44	13	472-474
1	TEF4	4	19	10	455-459
1	TEF4	4	19	11	488-490
1	TEF4	4	44	13	470-472
1	TEF4	4	43	6	412
1	TEF4	4	43	9	362
1	TEF4	4	43	12	514-517
1	TOG3	3	46	2	23-26
1	TOG3	3	46	8	152-155
1	TOG3	3	46	11	232-234
1	TOG3	3	46	11	236-241
1	TOG3	3	46	11	265-277
1	TEL2	2	26	14	387-422
1	TEL2	2	26	18	479-494
1	TEL2	2	26	6	185-209
1	TEL2	2	26	8	226-245
1	TOG4	4	46	3	29-33
1	TOG4	4	46	3	40
1	TOG4	4	8	3	51-56
1	TOG4	4	8	3	56-58
1	TOG4	4	8	3	60-63
1	TOG4	4	8	3	63-70
1	TEJ1	1	26	1	1-8
1	TEJ1	1	26	1	1-9
1	TEJ1	1	26	1	10-30
1	TEJ1	1	26	2	39-55
1	TEJ1	1	26	5	143-177
1	TEJ1	1	26	22	631-659
1	TDA1	1	34	3	95
1	TDA2	2	34	11	530-536
1	TDA2	2	34	7	315-318

TABLE:-ON THE THEORY NEED PER INSTRUCTIONAL
OFFERING PER YEAR WITH REFERENCE
TO TEXT CHAPTER AND PAGE.

MATHS	SUBJECT	YEAR	TEXT	CHAPT.	PAGES
1	TDA2	2	34	7	324-328
1	TDA2	2	34	7	328-331
1	TEH4	4	11	1	16-17
1	TEH4	4	11	9	300-306
1	TEI1	1	17	3	66-120
1	TEI1	1	17	4	126-134
1	TEI1	1	17	5	150-183
1	TEI2	2	5	3	48-77
1	TEI2	2	5	5	134-197
1	TEI2	2	5	11	417-464
1	TEI2	2	5	15	644-670
1	TEI2	2	5	16	703-754
1	TEH4	4	56	19	412-418
1	TEH4	4	56	20	427-454
1	TEH4	4	56	21	457-472
1	TEH4	4	56	22	475-495
1	TEH4	4	56	18	394-410
1	TEH4	4	31	2	22-28
1	TEK3	3	18	6	137-142
1	TEK2	2	26	19	506-515
1	TEK2	2	26	22	631-659
1	TIC1	1	64	1	19-43
1	TIC1	1	64	1	43-46
1	TIC1	1	64	3	185-203
1	TIC1	1	64	2	108-122
1	TIC1	1	64	4	251-286
1	TIC1	1	64	4	309-313
1	TIC1	1	64	4	315-331
1	TIC1	1	64	4	331-354
1	TTC3	3	62	8	153-172
1	TTC3	3	62	13	239-253
1	TTC3	3	62	10	183-194
1	TTC3	3	62	A2	261-271
1	TTC3	3	62	11	195-238
1	TEG3	3	2	2	25-64
1	TEG3	3	2	6	127-146
1	TEG3	3	2	7	149-189
1	TEG3	3	4	13	552-555
1	TEG3	3	2	16	505-524
1	TIC2	2	36	7	17-32
1	TIC2	2	36	1	1 -13
1	TIC2	2	36	2	1- 15
1	TIC2	2	36	3	1- 55
1	TIC2	2	36	5	1-39
1	TIC2	2	36	6	1-21
1	TIC3	3	37	1	1-40
1	TEK4	4	18	9	235-240
1	TEK4	4	18	8	202-210
1	TEH3	3	54	1	2-3

TABLE:-ON THE THEORY NEED PER INSTRUCTIONAL OFFERING PER YEAR WITH REFERENCE TO TEXT CHAPTER AND PAGE.

MATHS	SUBJECT	YEAR	TEXT	CHAPT.	PAGES
1	TIA3	3	50	20	361-375
1	TIA3	3	50	33	537-547
1	TIA3	3	50	1	18-20
1	TEF2	2	43	5	142-152
1	TEF2	2	42	5	124-135
1	TEF2	2	42	8	204-206
1	TRB3	3	41	5	149-157
1	TRB3	3	41	10	329-331
1	TRB3	3	55	2	10-11
1	TTB2	2	41	9	293-315
1	TTB2	2	30	9	248-278
1	TRB3	3	30	7	150-206
1	TEF2	2	57	19	716-761
1	TEF4	4	44	13	480-483
1	TOG3	3	46	2	18-23
1	TOG4	4	8	3	47-51
1	TOG4	4	8	3	59-60
1	TEJ1	1	26	3	58-97
1	TEJ1	1	26	4	105-134
1	TEJ1	1	26	10	266-282
1	TEH4	4	11	9	306-323
1	TEI1	1	17	6	188-224
1	TEI1	1	17	7	228-270
1	TEI1	1	17	8	274-296
1	TEI1	1	17	16	602-656
1	TEK3	3	18	7	193-197
1	TEK3	3	18	7	163-173
1	TEK2	2	18	1	13-17
1	TEK2	2	44	25	813-814
1	TTC3	3	60	2	24-39
1	TIC2	2	36	7	1-46
1	TEK4	4	18	10	271-287
1	TEK4	4	18	1	13 - 15
1	TEK4	4	18	7	190-192
1	TEK4	4	18	8	220-230
1	TEH3	3	54	3	45-49
1	TEH3	3	54	13	219-220
1	TEH4	4	54	3	45-49
1	TEH4	4	54	13	219-220
1	TEF2	2	43	5	171-173
1	TRB3	3	41	8	274-279
1	TRB3	3	41	10	329-331
1	TRB3	3	41	5	167-175
1	TTB2	2	41	12	393-441
1	TTB2	2	41	8	255-290
1	TTB2	2	41	15	511-561
1	TTB2	2	55	4	43-49
1	TTB2	2	30	4	67-75
1	TRB3	3	30	4	71-87

TABLE:-ON THE THEORY NEED PER INSTRUCTIONAL
OFFERING PER YEAR WITH REFERENCE
TO TEXT CHAPTER AND PAGE.

MATHS	SUBJECT	YEAR	TEXT	CHAPT.	PAGES
1	TRB3	3	30	6	126-146
1	TEH3	3	56	21	457-472
1	TEH3	3	56	22	475-495
1	TEF4	4	44	12	393-414
1	TOG3	3	46	8	165-169
1	TEL2	2	26	16	446-456
1	TOG4	4	8	6	154-159
1	TOG4	4	23	16	380-390
1	TEK3	3	44	4	93-130
1	TEK3	3	18	7	174-184
1	TEK3	3	26	21	603-626
1	TEH3	3	11	6	178-197
1	TEF2	2	42	1	8-22
1	TTB2	2	41	10	329-374
1	TTB2	2	30	8	210-246
1	TTB2	2	30	4	67-85
1	TIB3	3	67	19	245-251
1	TEF4	4	19	7	328-351
1	TEL2	2	26	13	359-381
1	TOG4	4	8	11	300-307
1	TEK3	3	18	7	184-197
1	TEK3	3	18	4	76-96
1	TEK2	2	26	11	288-329
1	TEK2	2	26	13	361-381
1	TEK2	2	26	10	268-282
1	TIA3	3	50	5	96-100
1	TEF2	2	43	8	282-288
1	TRB3	3	13	11	243-280
1	TTB2	2	55	2	6-25
1	TTB2	2	30	5	88-123
1	TTB2	2	33	8	122-140
1	TOG4	4	8	3	40-47
1	TIB3	3	6	8	26-29
1	TIC1	1	6	11	3-7
1	TIJ1	1	74	2	14-54
1	TIJ1	1	74	3	62-113
1	TIJ1	1	74	4	118-153
1	TIJ1	1	74	8	291-332
1	TIJ1	1	74	11	418-465
1	TIJ1	1	74	13	521-578
1	TIJ1	1	74	14	592-633
1	TDA3	3	75	11	383-429
1	TSH2	2	76	1	1-20
1	TSH2	2	76	4	68-80
1	TSH2	2	76	9	177-196
1	TIJ1	1	74	16	708-754
1	TSH2	2	76	2	21-38
1	TSH3	3	78	5	36-47
1	TSH3	3	78	6	48-55

TABLE:-ON THE THEORY NEED PER INSTRUCTIONAL OFFERING PER YEAR WITH REFERENCE TO TEXT CHAPTER AND PAGE.

MATHS	SUBJECT	YEAR	TEXT	CHAPT.	PAGES
1	TSH3	3	78	9	91-108
1	TSH3	3	78	12	135-145
1	TSH3	3	78	15	173-192
1	TSH3	3	78	16	181-192
1	TSH3	3	78	17	193-198
1	TSH4	4	79	3	34-54
1	TSH4	4	76	13	263-273
1	TSH4	4	76	14	277-289
1	TSH4	4	76	5	81-92
1	TSH4	4	76	9	181-183
1	TEI3	3	10	16	471-511
1	TEI3	3	10	11	309-354
1	TEI3	3	10	12	355-388
1	TEI3	3	10	13	389-428
1	TEI3	3	10	14	429-447
1	TEI3	3	10	15	449-469
1	TEI3	3	10	7	208-212
2	TEH3	3	54	1	2-3
2	TRB3	3	41	5	149-157
2	TTB2	2	41	8	255-290
2	TTB2	2	30	9	248-278
2	TTB2	2	30	9	249-256
2	TRB3	3	30	5	99-100
2	TEH3	3	56	21	457-472
2	TIB3	3	68	11	477-478
2	TDA2	2	34	11	549-562
2	TIC3	3	37	4	1-45
2	TEK4	4	18	10	271-287
2	TEK4	4	18	2	38-55
2	TEK4	4	18	7	184-190
2	TEK4	4	18	8	212-217
2	TEF2	2	42	3	70-79
2	TRB3	3	41	5	178-184
2	TRB3	3	41	7	227-246
2	TTB2	2	41	12	393-441
2	TTB2	2	33	8	122-140
2	TEF2	2	58	6	172-179
2	TEH3	3	56	19	412-425
2	TEH3	3	56	22	475-495
2	TTC4	4	61	3	26-38
2	TIB3	3	68	11	471-475
2	TDA1	1	34	2	28-65
2	TEH4	4	31	2	9-16
2	TEH4	4	31	2	22-28
2	TIC1	1	64	1	19-43
2	TIC2	2	36	1	1 -13
2	TIC2	2	36	2	1- 15
2	TIC2	2	36	3	1- 55
2	TIC3	3	37	1	1-40

TABLE:-ON THE THEORY NEED PER INSTRUCTIONAL OFFERING PER YEAR WITH REFERENCE TO TEXT CHAPTER AND PAGE.

MATHS	SUBJECT	YEAR	TEXT	CHAPT.	PAGES
2	TEK4	4	18	9	235-240
2	TEK4	4	18	8	202-210
2	TIC2	2	36	7	17-32
2	TRB3	3	13	4	60-89
2	TTB2	2	30	8	210-246
2	TTB2	2	30	4	67-85
2	TEJ1	1	26	5	143-177
2	TEI2	2	5	5	134-197
2	TEI2	2	5	11	417-464
2	TIC2	2	36	7	17-32
2	TEF2	2	43	8	282-288
2	TTB2	2	55	2	6-25
2	TTB2	2	30	5	88-123
2	TTB2	2	33	7	104-120
2	TTB2	2	30	4	67-75
2	TIC2	2	36	5	1-39
2	TTB2	2	55	3	26-42
2	TTB2	2	33	6	94-102
2	TTC4	4	60	3	42-61
2	TEK3	3	18	7	184-197
2	TIC2	2	36	7	1-46
2	TIB3	3	6	8	26-29
2	TIJ1	1	74	8	291-332
2	TIJ1	1	74	13	521-578
2	TDA3	3	75	11	383-429
2	TSH2	2	76	1	1-20
2	TSH2	2	76	4	68-80
2	TSH2	2	76	9	176-197
2	TSH3	3	78	5	36-47
2	TSH3	3	78	6	48-55
2	TSH3	3	78	9	91-108
2	TSH3	3	78	12	135-145
2	TSH3	3	76	7	138-155
2	TSH3	3	78	17	193-198
2	TSH4	4	76	13	263-273
2	TSH4	4	76	12	252
2	TSH4	4	76	1	9-10
3	TRB3	3	13	2	24-38
3	TTB2	2	41	12	393-441
3	TTB2	2	55	2	6-25
3	TEH3	3	56	18	394-411
3	TEH3	3	56	22	475-495
3	TOG3	3	46	8	163-165
3	TEK3	3	18	7	174-184
3	TEF2	2	42	4	93-98
3	TTB2	2	30	8	210-246
3	TTB2	2	33	[illegible]	76-80
3	TTB2	2	30	9	249-256
3	TEH3	3	56	21	457-472

TABLE:-ON THE THEORY NEED PER INSTRUCTIONAL OFFERING PER YEAR WITH REFERENCE TO TEXT CHAPTER AND PAGE.

MATHS	SUBJECT	YEAR	TEXT	CHAPT.	PAGES
3	TOG3	3	46	11'	236-241
3	TEI2	2	5	11	417-464
3	TEH4	4	56	22	475-495
3	TEH4	4	56	18	394-410
3	TTC3	3	62	A2	261-271
3	TRB3	3	41	5	149-157
3	TTB2	2	55	5	50-68
3	TTB2	2	30	9	248-278
3	TTB2	2	33	7	104-120
3	TEH4	4	56	21	457-472
3	TEK3	3	18	7	193-197
3	TEK3	3	18	5	109-129
3	TIC3	3	37	1	1-40
3	TEK4	4	18	9	235-240
3	TRB3	3	13	4	60-89
3	TRB3	3	13	11	243-280
3	TOG3	3	46	6	106-114
3	TEH4	4	11	9	306-323
3	TEK4	4	18	7	164-171
3	TRB3	3	30	6	126-146
3	TEJ1	1	26	4	105-134
3	TIJ1	1	74	8	291-332
3	TIJ1	1	74	11	418-465
3	TDA3	3	75	2	27-65
3	TSH2	2	76	1	1-20
3	TDA4	4	77	2	15-76
3	TSH3	3	78	15	173-192
3	TSH4	4	76	13	263-273
3	TEI3	3	10	7	208-212
4	TSH2	2	76	2	21-38
4	TSH3	3	78	7	56-65
5	TOG4	4	8	11	308-313
5	TOG3	3	46	8	157-161
5	TOG3	3	46	9	177-182
6	TEH3	3	54	13	219-220
6	TEH4	4	54	13	219-220
6	TTC4	4	60	3	42-61
6	TIC2	2	36	5	1-39
6	TEF2	2	57	19	716-761
6	TIJ1	1	74	12	477-520
6	TIJ1	1	74	13	521-578
6	TSH3	3	78	5	36-47.
6	TSH4	4	79	3	34-54
7	TOG3	3	46	8	157-161
7	TOG4	4	46	5	88-90
7	TIJ1	1	74	3	62-113
7	TIJ1	1	74	12	477-520
9	TOG4	4	46	5	81-86
9	TOG4	4	46	5	86-88

TABLE:-ON THE THEORY NEED PER INSTRUCTIONAL OFFERING PER YEAR WITH REFERENCE TO TEXT CHAPTER AND PAGE.

MATHS	SUBJECT	YEAR	TEXT	CHAPT.	PAGES
9	TOG4	4	46	5	88-90
9	TOG4	4	46	5	94-98
9	TOG4	4	8	3	40-47
9	TOG4	4	8	3	51-56
9	TOG4	4	8	3	63-70
9	TOG4	4	46	5	90-94
10	TIB3	3	72	11	405-409
10	TIB3	3	72	11	415-418
10	TIB3	3	72	11	422-436
10	TTC4	4	38	7	41-83
10	TEF2	2	42	6	140-147
10	TEF2	2	42	8	189-191
10	TEI2	2	5	3	48-77
10	TEF2	2	42	5	124-135
10	TEI1	1	17	8	274-296
10	TEF3	3	44	9	290-294
10	TRB3	3	41	10	329-331
10	TTB2	2	41	12	393-441
10	TRB3	3	30	7	150-206
10	TEF3	3	44	9	290-294
10	TIC2	2	36	1	1 -13
10	TIC2	2	36	3	1- 55
10	TRB3	3	41	5	167-175
12	TOG3	3	46	4	64-68
12	TOG3	3	46	4	61-64
12	TEJ1	1	26	4	105-134
13	TIC2	2	36	1	1 -13
14	TEF3	3	44	9	285-287
14	TEF3	3	26	12	486
14	TEK4	4	18	10	271-287
14	TEK4	4	18	8	220-230
14	TIA3	3	50	33	548-553
14	TIA3	3	50	33	537-547
14	TIA3	3	50	1	18-20
14	TEF2	2	43	8	250-252
14	TRB3	3	41	10	346-349
14	TRB3	3	41	10	329-331
14	TRB3	3	41	5	167-175
14	TRB3	3	55	2	10-11
14	TRB3	3	13	3	39-59
14	TRB3	3	13	11	243-280
14	TTB2	2	41	9	293-315
14	TTB2	2	41	10	329-374
14	TTB2	2	41	11	377-390
14	TTB2	2	55	2	6-25
14	TTB2	2	55	5	50-68
14	TTB2	2	30	5	88-123
14	TTB2	2	30	4	67-75
14	TTB2	2	30	5	88-98

TABLE:-ON THE THEORY NEED PER INSTRUCTIONAL OFFERING PER YEAR WITH REFERENCE TO TEXT CHAPTER AND PAGE.

MATHS	SUBJECT	YEAR	TEXT	CHAPT.	PAGES
14	TEK4	4	52	18	478-481
14	TEF2	2	58	5	138-142
14	TTC4	4	61	6	76-109
14	TEF3	3	44	9	285-287
14	TEF3	3	26	12	486
14	TEF4	4	44	12	393-414
14	TEL2	2	44	5	134-167
14	TEL2	2	26	13	359-381
14	TEK3	3	18	7	163-173
14	TEF3	3	44	9	290-294
14	TEF3	3	44	13	439-442
14	TEF3	3	44	13	462-470
14	TEF3	3	43	15	429-442
14	TEK4	4	18	7	164-171
14	TEK4	4	50	5	92-96
14	TEK4	4	50	33	543-545
14	TEH3	3	11	6	178-197
14	TIA3	3	50	1	14-16
14	TIA3	3	50	5	96-100
14	TIA3	3	50	23	426-430
14	TEF2	2	43	5	171-173
14	TRB3	3	41	10	320-329
14	TRB3	3	41	15	511-553
14	TTB2	2	41	12	393-441
14	TTB2	2	41	8	255-290
14	TTB2	2	41	10	319-329
14	TTB2	2	41	15	511-561
14	TTB2	2	55	3	26-42
14	TTB2	2	55	4	43-49
14	TTB2	2	30	4	67-85
14	TRB3	3	30	6	126-146
14	TRB3	3	30	5	99-100
14	TEF3	3	44	9	290-294
14	TEF3	3	44	13	439-442
14	TEF3	3	44	13	462-470
14	TEF3	3	43	15	429-442
14	TEF4	4	26	17	457-466
14	TEF4	4	26	17	467-476
14	TOG3	3	46	4	72-76
14	TEL2	2	26	16	446-456
14	TEL2	2	26	18	479-494
14	TEK3	3	18	4	76-96
14	TEK3	3	26	21	603-626
14	TEK2	2	26	11	288-329
14	TEK2	2	44	5	134-167
14	TTC3	3	62	8	153-172
14	TEF2	2	43	5	142-152
14	TEF2	2	43	8	282-288
14	TEF2	2	42	9	211-225

TABLE:-ON THE THEORY NEED PER INSTRUCTIONAL OFFERING PER YEAR WITH REFERENCE TO TEXT CHAPTER AND PAGE.

MATHS	SUBJECT	YEAR	TEXT	CHAPT.	PAGES
14	TTB2	2	33	8	122-140
14	TTB2	2	33	6	94-102
14	TEF2	2	57	19	716-761
14	TTC4	4	60	3	42-61
14	TIB3	3	67	19	245-251
14	TEF4	4	44	12	415-431
14	TEF4	4	44	13	470-472
14	TOG3	3	46	11	236-241
14	TEL2	2	26	14	387-422
14	TEH4	4	11	9	306-323
14	TEI2	2	5	14	551-631
14	TEI2	2	5	15	644-670
14	TEK3	3	18	7	184-197
14	TEK2	2	26	13	361-381
14	TEK2	2	26	10	268-282
14	TEK2	2	44	25	813-814
14	TTC3	3	62	A2	261-271
14	TEG3	3	4	13	552-555
14	TEK4	4	18	1	13 - 15
14	TEK4	4	18	7	190-192
14	TOG3	3	46	6	101-106
14	TEI2	2	5	3	48-77
14	TEK2	2	18	1	13-17
14	TEK4	4	18	7	184-190
14	TTB2	2	30	9	248-278
14	TTB2	2	33	7	104-120
14	TEK3	3	44	4	93-130
14	TIC2	2	36	3	1- 55
14	TIJ1	1	74	3	62-113
14	TIJ1	1	74	4	118-153
14	TIJ1	1	74	5	154-201
14	TIJ1	1	74	8	291-332
14	TIJ1	1	74	11	418-465
14	TIJ1	1	74	13	521-578
14	TIJ1	1	74	14	592-633
14	TIJ1	1	74	16	708-754
14	TSH2	2	76	9	177-196
14	TDA4	4	77	2	15-76
14	TDA4	4	77	10	279-303
14	TSH3	3	78	9	91-108
14	TSH3	3	76	7	138-155
14	TSH3	3	78	15	173-192
14	TSH3	3	78	16	181-192
14	TSH4	4	79	3	34-54
15	TRB3	3	55	2	11-14
15	TTB2	2	55	3	26-42
15	TTB2	2	55	4	43-49
15	TTB2	2	30	4	67-85
15	TTB2	2	33	7	104-120

TABLE:-ON THE THEORY NEED PER INSTRUCTIONAL
OFFERING PER YEAR WITH REFERENCE
TO TEXT CHAPTER AND PAGE.

MATHS	SUBJECT	YEAR	TEXT	CHAPT.	PAGES
15	TTB2	2	33	8	122-140
15	TTB2	2	35	9	299-312
15	TRB3	3	30	4	71-87
15	TRB3	3	30	6	126-146
15	TEH3	3	56	20	427-454
15	TIB3	3	72	11	410-411
15	TIB3	3	72	4	133-140
15	TIB3	3	72	6	180-188
15	TIB3	3	72	4	144-149
15	TEF4	4	19	11	507-512
15	TEF4	4	19	11	514-519
15	TEF4	4	43	10	447-451
15	TEJ1	1	26	10	266-282
15	TEF2	2	42	9	211-225
15	TRB3	3	41	8	274-279
15	TRB3	3	41	5	167-175
15	TRB3	3	13	4	60-89
15	TRB3	3	13	11	243-280
15	TTB2	2	41	10	329-374
15	TTB2	2	55	2	6-25
15	TTB2	2	55	5	50-68
15	TTB2	2	30	4	67-75
15	TTB2	2	30	5	88-98
15	TEK4	4	52	18	478-481
15	TEH3	3	59	6	90
15	TIB3	3	68	11	500-502
15	TEF4	4	19	7	328-351
15	TEF4	4	44	13	470-472
15	TOG3	3	46	2	26-27
15	TRB3	3	41	10	320-329
15	TRB3	3	41	7	227-246
15	TTB2	2	41	12	393-441
15	TTB2	2	41	10	319-329
15	TRB3	3	30	7	150-206
15	TEH3	3	56	19	412-425
15	TTB2	2	41	8	255-290
15	TTB2	2	41	15	511-561
15	TTB2	2	30	8	210-246
15	TEF4	4	44	12	393-414
15	TIC3	3	37	1	1-40
15	TIJ1	1	74	2	14-54
15	TDA4	4	77	2	15-76
15	TDA4	4	77	3	77-116
16	TEF3	3	44	9	281-283
16	TEF3	3	44	9	283-284
16	TEF3	3	44	13	457-458
16	TRB3	3	41	5	178-184
16	TRB3	3	41	15	511-553
16	TTB2	2	41	15	511-561

TABLE:-ON THE THEORY NEED PER INSTRUCTIONAL OFFERING PER YEAR WITH REFERENCE TO TEXT CHAPTER AND PAGE.

MATHS	SUBJECT	YEAR	TEXT	CHAPT.	PAGES
16	TTB2	2	30	8	210-246
16	TTB2	2	30	5	88-123
16	TTB2	2	33	8	122-140
16	TEF2	2	57	19	716-761
16	TEF3	3	44	9	281-283
16	TEF3	3	44	9	283-284
16	TEF3	3	44	13	457-458
16	TEF4	4	44	13	480-483
16	TOG3	3	46	6	106-114
16	TOG3	3	46	8	165-169
16	TOG3	3	46	9	171-174
16	TOG3	3	46	9	177-182
16	TEI2	2	5	14	551-631
16	TEK3	3	44	4	93-130
16	TEK3	3	18	7	184-197
16	TEF3	3	44	9	285-287
16	TEF3	3	44	9	295-300
16	TEF3	3	44	9	306-308
16	TEF3	3	44	13	445-450
16	TEF3	3	44	13	459-462
16	TEK4	4	18	1	13 - 15
16	TEK4	4	18	7	190-192
16	TEF2	2	43	8	250-252
16	TEF2	2	43	8	282-288
16	TTB2	2	33	7	104-120
16	TTB2	2	33	6	94-102
16	TEH3	3	56	20	427-454
16	TIB3	3	67	19	245-251
16	TEF3	3	44	9	285-287
16	TEF3	3	44	9	295-300
16	TEF3	3	44	9	306-308
16	TEF3	3	44	13	445-450
16	TEF3	3	44	13	459-462
16	TEF4	4	19	6	311-320
16	TEF4	4	44	12	415-431
16	TEF4	4	19	10	455-459
16	TOG3	3	46	6	101-106
16	TOG4	4	8	6	160-164
16	TEH4	4	56	20	427-454
16	TEK3	3	18	5	109-129
16	TEG3	3	2	7	149-189
16	TEG3	3	4	13	552-555
16	TEF3	3	44	13	462-470
16	TRB3	3	13	11	243-280
16	TTB2	2	33	6	90-94
16	TEF3	3	44	13	462-470
16	TEF4	4	19	7	328-351
16	TOG3	3	46	4	64-68
16	TEI2	2	5	16	703-754

TABLE:-ON THE THEORY NEED PER INSTRUCTIONAL OFFERING PER YEAR WITH REFERENCE TO TEXT CHAPTER AND PAGE.

MATHS	SUBJECT	YEAR	TEXT	CHAPT.	PAGES
16	TOG4	4	23	14	331-347
16	TEH4	4	56	22	475-495
16	TEK2	2	18	1	13-17
16	TEK4	4	18	7	184-190
16	TEF2	2	43	5	171-173
16	TRB3	3	41	5	149-157
16	TTB2	2	41	12	393-441
16	TEH3	3	56	22	475-495
16	TEF4	4	44	12	393-414
16	TEI1	1	17	16	602-656
16	TEK2	2	44	5	134-167
16	TTB2	2	41	10	329-374
16	TTB2	2	55	4	43-49
16	TRB3	3	30	7	150-206
16	TEL2	2	44	5	134-167
16	TEI3	3	10	12	355-388
17	TEF3	3	44	9	317-320
17	TEK4	4	18	10	265
17	TEK4	4	18	1	13 - 15
17	TEK4	4	18	7	190-192
17	TEF2	2	43	5	142-152
17	TEF2	2	43	5	171-173
17	TTB2	2	33	6	94-102
17	TRB3	3	30	5	120-123
17	TEF2	2	57	19	716-761
17	TTC4	4	60	3	42-61
17	TEF3	3	44	9	317-320
17	TEF4	4	19	6	311-320
17	TEF4	4	26	17	457-466
17	TEF4	4	44	12	415-431
17	TEF4	4	19	7	328-351
17	TEF4	4	26	17	467-476
17	TOG3	3	46	6	101-106
17	TOG3	3	46	8	161-163
17	TEK2	2	26	13	361-381
17	TEK2	2	26	10	268-282
17	TEK2	2	18	1	13-17
17	TEF3	3	44	9	281-283
17	TEF3	3	44	9	300-302
17	TEF3	3	26	5	154-159
17	TEF3	3	44	13	457-458
17	TEF3	3	26	12	486
17	TRB3	3	41	10	346-349
17	TTB2	2	30	5	88-123
17	TEF3	3	44	9	281-283
17	TEF3	3	44	9	300-302
17	TEF3	3	26	5	154-159
17	TEF3	3	44	13	457-458
17	TEF3	3	26	12	486

TABLE:-ON THE THEORY NEED PER INSTRUCTIONAL
OFFERING PER YEAR WITH REFERENCE
TO TEXT CHAPTER AND PAGE.

MATHS	SUBJECT	YEAR	TEXT	CHAPT.	PAGES
17	TEF4	4	44	12	393-414
17	TOG3	3	46	8	163-165
17	TOG3	3	46	8	165-169
17	TEL2	2	26	13	359-381
17	TEL2	2	26	14	387-422
17	TEK3	3	44	4	93-130
17	TEK3	3	18	7	184-197
17	TTC3	3	62	10	183-194
17	TEF3	3	44	9	285-287
17	TEF3	3	44	9	306-308
17	TEF3	3	44	9	290-294
17	TEF3	3	44	13	459-462
17	TEK4	4	18	7	184-190
17	TTB2	2	55	2	6-25
17	TEF3	3	44	9	285-287
17	TEF3	3	44	9	306-308
17	TEF3	3	44	9	290-294
17	TEF3	3	44	13	459-462
17	TEG3	3	2	7	149-189
17	TEF3	3	44	13	462-470
17	TTB2	2	55	3	26-42
17	TTB2	2	55	4	43-49
17	TEF3	3	44	13	462-470
17	TOG3	3	46	4	64-68
17	TEJ1	1	26	10	266-282
17	TTB2	2	41	12	393-441
17	TOG4	4	23	14	331-347
17	TEK2	2	26	11	288-329
17	TTC4	4	7	7	115
17	TSH2	2	76	4	68-80
18	TEF3	3	26	5	189-196
18	TEF3	3	44	13	454-457
18	TEK4	4	18	9	235-240
18	TEK4	4	50	5	88-92
18	TIC2	2	36	7	1 - 16
18	TIC2	2	36	7	33-46
18	TEH3	3	11	6	178-197
18	TEH3	3	11	8	283-284
18	TEH3	3	11	8	277-282
18	TEH3	3	11	6	170-171
18	TEH3	3	11	6	177-178
18	TIA3	3	50	2	29-31
18	TIA3	3	50	2	31-32
18	TIA3	3	50	1	14-16
18	TIA3	3	50	20	361-375
18	TIA3	3	50	4	70-73
18	TIA3	3	50	1	4-5
18	TIA3	3	50	23	423-425
18	TEF2	2	43	5	189-192

TABLE:-ON THE THEORY NEED PER INSTRUCTIONAL OFFERING PER YEAR WITH REFERENCE TO TEXT CHAPTER AND PAGE.

MATHS	SUBJECT	YEAR	TEXT	CHAPT.	PAGES
18	TEF2	2	43	8	282-288
18	TEF2	2	42	10	254-256
18	TEF2	2	42	10	270-272
18	TEF2	2	42	10	274-277
18	TEF2	2	42	4	93-98
18	TEF2	2	42	5	108-113
18	TEF2	2	42	1	8-22
18	TEF2	2	42	2	39
18	TEF2	2	42	5	95-98
18	TEF2	2	42	5	124-135
18	TEF2	2	42	6	140-147
18	TEF2	2	42	8	189-191
18	TEF2	2	42	8	193-196
18	TEF2	2	42	8	204-206
18	TEF2	2	42	9	211-225
18	TRB3	3	41	8	274-279
18	TRB3	3	13	4	60-89
18	TRB3	3	30	7	150-206
18	TEF2	2	58	4	112-118
18	TEF2	2	58	5	134-136
18	TEF2	2	58	6	187-188
18	TEF2	2	58	9	266
18	TEH3	3	59	6	90
18	TEH3	3	59	AF	111-112
18	TEH3	3	59	AF	112-113
18	TTC4	4	61	2	12-25
18	TTC4	4	61	3	26-38
18	TTC4	4	61	8	138-164
18	TIB3	3	65	6	315-316
18	TIB3	3	66	1	7-10
18	TIB3	3	66	3	41-46
18	TIB3	3	67	18	236-245
18	TIB3	3	69	14	593-595
18	TIB3	3	69	14	608-611
18	TIB3	3	70	9	289
18	TIB3	3	72	11	419-422
18	TIB3	3	72	5	155-157
18	TIB3	3	72	13	515-528
18	TEF3	3	26	5	189-196
18	TEF3	3	44	13	454-457
18	TOG3	3	46	4	69-72
18	TOG3	3	46	6	114-116
18	TOG3	3	46	6	117-118
18	TOG3	3	46	9	174-177
18	TOG3	3	46	9	182-188
18	TOG3	3	46	9	189-193
18	TOG3	3	46	11	226-232
18	TOG3	3	46	11	234-235
18	TEL2	2	26	16	446-456

TABLE:-ON THE THEORY NEED PER INSTRUCTIONAL
OFFERING PER YEAR WITH REFERENCE
TO TEXT CHAPTER AND PAGE.

MATHS	SUBJECT	YEAR	TEXT	CHAPT.	PAGES
18	TOG4	4	8	3	39-40
18	TOG4	4	8	6	160-164
18	TEJ1	1	26	3	58-97
18	TEJ1	1	26	4	105-134
18	TDA1	1	34	3	96-98
18	TDA2	2	34	11	542-544
18	TEH4	4	11	9	296-300
18	TEH4	4	11	9	306-323
18	TEI2	2	17	2	44-60
18	TEI1	1	17	6	188-224
18	TEI1	1	17	7	228-270
18	TEI1	1	17	8	274-296
18	TEI1	1	17	16	602-656
18	TOG4	4	23	14	321-331
18	TEK3	3	18	7	193-197
18	TEK3	3	26	21	603-626
18	TEK2	2	26	11	288-329
18	TEK2	2	44	25	813-814
18	TIC1	1	64	3	125-133
18	TTC3	3	60	2	24-39
18	TIC2	2	36	7	1 - 16
18	TIC2	2	36	7	33-46
18	TIC2	2	36	7	1-46
18	TEF3	3	44	14	488-501
18	TEF3	3	44	13	450-454
18	TEF3	3	44	13	472-474
18	TEK4	4	18	10	265
18	TIA3	3	50	3	47-49
18	TTC4	4	38	8	84-98
18	TEF2	2	43	2	26-34
18	TEF2	2	42	10	252-254
18	TTB2	2	41	11	377-390
18	TTB2	2	33	6	90-94
18	TRB3	3	30	4	71-87
18	TEF2	2	58	5	138-142
18	TEH3	3	56	18	394-411
18	TTC4	4	61	6	76-109
18	TIB3	3	68	11	477-478
18	TIB3	3	69	14	595-597
18	TIB3	3	72	11	422-436
18	TEF3	3	44	14	488-501
18	TEF3	3	44	13	450-454
18	TEF3	3	44	13	472-474
18	TOG3	3	46	4	77-79
18	TOG3	3	46	6	106-114
18	TOG3	3	46	9	171-174
18	TOG3	3	46	9	177-182
18	TOG3	3	46	11	232-234
18	TOG3	3	46	11	265-277

TABLE:-ON THE THEORY NEED PER INSTRUCTIONAL OFFERING PER YEAR WITH REFERENCE TO TEXT CHAPTER AND PAGE.

MATHS	SUBJECT	YEAR	TEXT	CHAPT.	PAGES
18	TEL2	2	44	5	134-167
18	TEL2	2	26	6	185-209
18	TEL2	2	26	8	226-245
18	TOG4	4	46	5	94-98
18	TOG4	4	8	6	154-159
18	TEJ1	1	26	5	143-177
18	TEJ1	1	26	22	631-659
18	TDA2	2	34	11	549-562
18	TEH4	.4	11	1	12-13
18	TEH4	4	11	1	14-15
18	TEH4	4	11	9	300-306
18	TEI1	1	17	3	66-120
18	TEI1	1	17	4	126-134
18	TEI1	1	17	5	150-183
18	TEI2	2	5	5	134-197
18	TEI2	2	5	14	551-631
18	TEI2	2	5	15	644-670
18	TEI2	2	5	16	703-754
18	TOG4	4	23	16	380-390
18	TEH4	4	56	19	412-418
18	TEH4	4	56	21	457-472
18	TEK2	2	26	13	361-381
18	TEK2	2	26	19	506-515
18	TEK2	2	26	10	268-282
18	TEK2	2	26	22	631-659
18	TIC1	1	64	3	185-203
18	TIC1	1	64	4	315-331
18	TTC3	3	62	13	239-253
18	TTC3	3	62	11	195-238
18	TEG3	3	2	2	25-64
18	TEG3	3	2	16	505-524
18	TIC3	3	37	4	1-45
18	TEF3	3	44	13	445-450
18	TIA3	3	50	5	96-100
18	TTB2	2	30	9	249-256
18	TEH3	3	56	20	427-454
18	TIB3	3	69	10	426-427
18	TEF3	3	44	13	445-450
18	TOG3	3	46	4	72-76
18	TEL2	2	26	13	359-381
18	TOG4	4	8	3	47-51
18	TOG4	4	8	11	308-313
18	TEJ1	1	26	1	10-30
18	TEH4	4	54	3	45-49
18	TEI2	2	5	3	48-77
18	TEH4	4	56	20	427-454
18	TEH4	4	56	18	394-410
18	TEK3	3	18	4	76-96
18	TEK2	2	44	5	134-167

TABLE:-ON THE THEORY NEED PER INSTRUCTIONAL OFFERING PER YEAR WITH REFERENCE TO TEXT CHAPTER AND PAGE.

MATHS	SUBJECT	YEAR	TEXT	CHAPT.	PAGES
18	TTC3	3	62	8	153-172
18	TTC3	3	62	10	183-194
18	TIC2	2	36	3	1- 55
18	TIC2	2	36	5	1-39
18	TEK4	4	18	8	202-210
18	TIA3	3	50	23	426-430
18	TEF2	2	43	5	142-152
18	TRB3	3	41	10	320-329
18	TTB2	2	33	6	94-102
18	TEF2	2	57	19	716-761
18	TTC4	4	60	3	42-61
18	TOG3	3	46	8	165-169
18	TOG3	3	46	11	236-241
18	TEL2	2	26	14	387-422
18	TOG4	4	8	3	40-47
18	TIC3	3	37	1	1-40
18	TEH3	3	56	22	475-495
18	TOG3	3	46	4	64-68
18	TEJ1	1	26	10	266-282
18	TEH4	4	56	22	475-495
18	TEK3	3	18	5	109-129
18	TIC1	1	6	11	3-7
18	TIB3	3	6	7	5-32
18	TIB3	3	6		36
					21
18	TIB3	3	6	16	7-15
18	TTC4	4	7	6	85-93
18	TTC4	4	7	11	218
					226
18	TIJ1	1	74	8	291-332
18	TIJ1	1	74	11	418-465
18	TDA3	3	75	11	383-429
18	TDA4	4	77	2	15-76
18	TDA4	4	77	3	77-116
18	TDA4	4	77	10	279-303
18	TSH2	2	76	2	21-38
18	TSH3	3	78	7	56-65
18	TEI3	3	10	16	471-513
18	TEI3	3	10	11	309-354
18	TEI3	3	10	12	355-388
18	TEI3	3	10	13	389-428
18	TEI3	3	10	14	429-447
19	TEF3	3	43	15	429-442
19	TIB3	3	67	19	245-251
19	TEF3	3	43	15	429-442
19	TEK4	4	18	7	164-171
19	TTB2	2	30	9	248-278
19	TTB2	2	30	5	88-98
19	TRB3	3	30	6	126-146

TABLE:-ON THE THEORY NEED PER INSTRUCTIONAL
OFFERING PER YEAR WITH REFERENCE
TO TEXT CHAPTER AND PAGE.

MATHS	SUBJECT	YEAR	TEXT	CHAPT.	PAGES
19	TTC4	4	7	'7	117
19	TIJ1	1	74	2	14-54
19	TIJ1	1	74	3	62-113
19	TIJ1	1	74	4	118-153
19	TIJ1	1	74	8	291-332
19	TIJ1	1	74	11	418-465
19	TIJ1	1	74	13	521-578
19	TIJ1	1	74	14	592-633
19	TIJ1	1	74	16	708-754
19	TDA4	4	75	1	2-25
20	TTB2	2	41	12	393-441
20	TTB2	2	33	8	122-140
20	TIB3	3	68	11	471-475
22	TOG3	3	46	7	155-157
22	TOG4	4	8	6	154-159
22	TIJ1	1	74	11	418-465
23	TTC4	4	38	7	41-83
23	TEF3	3	43	3	90-91
23	TEK4	4	18	8	220-230
23	TEF3	3	43	3	90-91
23	TIJ1	1	74	5	154-201
23	TIJ1	1	74	11	418-465
23	TSH4	4	76	13	263-273
24	TEK4	4	18	8	202-210
24	TIA3	3	50	5	96-100
24	TIA3	3	50	23	426-430
24	TOG3	3	46	4	72-76
24	TOG4	4	46	5	86-88
24	TOG4	4	46	5	90-94
24	TEF3	3	44	9	287-290
24	TEF3	3	44	13	454-457
24	TEF3	3	44	9	287-290
24	TEF3	3	44	13	454-457
24	TOG4	4	8	3	51-56
24	TEJ1	1	26	1	10-30
24	TEJ1	1	26	2	39-55
24	TEF2	2	42	1	8-22
24	TTB2	2	41	10	329-374
24	TEF2	2	58	5	138-142
24	TIB3	3	68	11	471-475
24	TEL2	2	26	18	479-494
24	TEJ1	1	26	4	105-134
24	TEI1	1	17	16	602-656
24	TEF3	3	44	9	285-287
24	TEK4	4	18	8	220-230
24	TEF2	2	42	9	211-225
24	TEF3	3	44	9	285-287
24	TEF4	4	44	12	415-431
24	TEJ1	1	26	5	143-177

TABLE:-ON THE THEORY NEED PER INSTRUCTIONAL OFFERING PER YEAR WITH REFERENCE TO TEXT CHAPTER AND PAGE.

MATHS	SUBJECT	YEAR	TEXT	CHAPT.	PAGES
24	TOG4	4	23	16	380-390
24	TOG4	4	23	14	321-331
24	TEK3	3	18	5	109-129
24	TIC2	2	36	7	1-46
24	TEL2	2	26	14	387-422
24	TEI2	2	5	14	551-631
24	TIB3	3	6	8	26-29
24	TIJ1	1	74	11	418-465
24	TIJ1	1	74	13	521-578
24	TIJ1	1	74	14	592-633
24	TSH2	2	76	1	1-20
24	TSH2	2	76	2	21-38
24	TSH3	3	78	9	91-108
24	TSH3	3	78	8	67-90
24	TSH3	3	76	7	138-155
24	TSH4	4	76	5	81-92
24	TSH4	4	76	9	181-183
25	TEH3	3	11	6	173-175
25	TIA3	3	50	4	76-80
25	TOG4	4	46	5	94-98
25	TOG4	4	8	8	185-187
25	TOG4	4	23	16	380-390
25	TOG4	4	23	14	331-347
25	TEK3	3	18	5	109-129
25	TEK2	2	44	5	134-167
25	TIC2	2	36	7	17-32
25	TTB2	2	30	5	88-123
25	TEF4	4	19	11	507-512
25	TOG3	3	46	4	69-72
25	TOG3	3	46	6	114-116
25	TOG4	4	46	3	29-33
25	TOG4	4	8	11	300-307
25	TOG4	4	8	11	308-313
25	TEK3	3	18	7	174-184
25	TIC2	2	36	7	17-32
25	TEK4	4	18	7	164-171
25	TEK4	4	50	5	92-96
25	TIA3	3	50	1	14-16
25	TIA3	3	50	23	426-430
25	TRB3	3	41	15	511-553
25	TTB2	2	55	3	26-42
25	TTB2	2	30	5	88-98
25	TEK4	4	52	18	478-481
25	TEF4	4	19	11	514-519
25	TOG4	4	46	5	90-94
25	TEJ1	1	26	10	266-282
25	TEK3	3	18	7	163-173
25	TIC2	2	36	7	1-46
25	TIA3	3	50	5	96-100

TABLE:-ON THE THEORY NEED PER INSTRUCTIONAL OFFERING PER YEAR WITH REFERENCE TO TEXT CHAPTER AND PAGE.

MATHS	SUBJECT	YEAR	TEXT	CHAPT.	PAGES
25	TTB2	2	41	10	319-329
25	TTB2	2	41	15	511-561
25	TEL2	2	44	5	134-167
25	TEI2	2	5	14	551-631
25	TEK3	3	44	4	93-130
25	TEK2	2	44	25	813-814
25	TRB3	3	41	10	320-329
25	TEF4	4	44	12	415-431
25	TEJ1	1	26	5	143-177
25	TEK2	2	26	10	268-282
25	TIJ1	1	74	5	154-201
25	TIJ1	1	74	8	281-332
25	TIJ1	1	74	11	418-465
25	TIJ1	1	74	13	521-578
25	TIJ1	1	74	14	592-633
25	TDA3	3	75	11	383-429
25	TSH2	2	76	1	1-20
25	TSH2	2	76	4	68-80
25	TSH2	2	76	9	177-196
25	TSH2	2	76	2	21-38
25	TSH3	3	78	9	91-108
25	TSH3	3	78	8	67-90
25	TSH4	4	76	1	9-10
25	TSH4	4	76	5	81-92
25	TSH4	4	76	9	181-183
26	TEF2	2	42	1	8-22
26	TEH3	3	54	13	219-220
26	TEH4	4	54	13	219-220
26	TOG4	4	23	14	321-331
26	TSH2	2	76	9	176-197
27	TOG4	4	23	14	321-331
27	TEH3	3	11	6	178-197
28	TOG3	3	46	2	16-18
28	TOG3	3	46	2	18-23
28	TOG3	3	46	2	26-27
28	TOG3	3	46	4	61-64
28	TOG4	4	46	3	33-38
28	TOG4	4	46	3	41-42
28	TOG4	4	46	3	42-47
28	TOG4	4	8	3	40-47
28	TOG4	4	8	3	47-51
28	TOG4	4	8	3	59-60
28	TEK3	3	18	4	76-96
28	TEF4	4	19	11	514-519
28	TOG3	3	46	2	23-26
28	TOG4	4	46	5	81-86
28	TOG4	4	8	3	63-70
28	TEF4	4	19	11	507-512
28	TOG4	4	8	11	300-307

TABLE:-ON THE THEORY NEED PER INSTRUCTIONAL
OFFERING PER YEAR WITH REFERENCE
TO TEXT CHAPTER AND PAGE.

MATHS	SUBJECT	YEAR	TEXT	CHAPT.	PAGES
28	TOG4	4	23	14	321-331
28	TEK2	2	26	11	288-329
28	TEK4	4	52	18	478-481
28	TOG4	4	23	14	331-347
28	TEK3	3	18	7	174-184
28	TOG4	4	23	16	380-390
28	TSH3	3	76	7	138-155
29	TOG4	4	8	11	300-307
30	TOG3	3	46	2	14-16
30	TOG3	3	46	4	68-69
30	TOG3	3	46	4	77-79
30	TOG4	4	46	5	88-90
30	TOG3	3	46	4	64-68
30	TOG3	3	46	7	155-157
30	TOG3	3	46	9	182-188
30	TOG4	4	46	5	90-94
30	TOG4	4	8	3	39-40
30	TOG4	4	8	3	40-47
30	TOG4	4	8	3	60-63
30	TOG3	3	46	4	61-64
31	TIB3	3	69	10	426-427
34	TEF3	3	26	5	154-159
34	TEF3	3	26	5	154-159
34	TTB2	2	55	2	6-25
34	TIB3	3	69	10	426-427
34	TOG4	4	23	14	331-347
34	TTB2	2	41	9	293-315
34	TRB3	3	41	5	167-175
34	TTB2	2	41	8	255-290
37	TEH3	3	54	13	217
37	TEH3	3	54	13	219-220
37	TEH4	4	54	13	217
37	TEH4	4	54	13	219-220
38	TEH3	3	11	1	12-14
38	TEH3	3	54	3	45-49
38	TEH3	3	54	7	123
38	TEH4	4	54	3	45-49
38	TIC3	3	37	4	1-45
39	TEH3	3	11	1	10-12
39	TEH3	3	54	3	45-49
39	TEH4	4	54	3	45-49
39	TEH4	4	54	4	68-70
39	TEH4	4	11	1	10-11
39	TEH3	3	11	1	4-6
39	TEH3	3	54	4	69-70
39	TEH4	4	54	3	45-49
40	TEH3	3	54	7	123
40	TEH4	4	11	1	12-13
40	TEH4	4	11	1	14-15

TABLE:-ON THE THEORY NEED PER INSTRUCTIONAL OFFERING PER YEAR WITH REFERENCE TO TEXT CHAPTER AND PAGE.

MATHS	SUBJECT	YEAR	TEXT	CHAPT.	PAGES
41	TEH4	4	54	3	45-49
41	TEL2	2	44	5	134-167
42	TEH3	3	54	4	69-70
42	TEH4	4	11	1	12
42	TEH4	4	54	4	69-70
42	TIC3	3	37	1	1-40
42	TEH4	4	54	4	68-70
43	TDA1	1	34	2	28-65
43	TDA1	1	34	4	126-148
43	TDA1	1	34	5	158-196
43	TDA1	1	34	6	200-272
43	TDA2	2	34	11	530-536
43	TDA1	1	34	2	24-59
43	TDA1	1	34	8	290-342
43	TDA1	1	34	12	486-510
43	TDA2	2	34	6	170-236
43	TDA3	3	75	11	383-429
43	TDA4	4	75	1	2-25
43	TDA4	4	75	5	145-177

*** Total ***
15357 3150 ****