Ⅱ－7　工学部　建築土木学科　建築

JOMO KENYATTA COLLEGE OF AGRICULTURE & TECHNOLOGY

SYLLABUS

FOR

ARCHITECTURAL TECHNICIANS CERTIFICATE

INTRODUCTION

GENERAL

1.1 The Jomo Kenyatta College of Agriculture and Technology process to provide a scheme for the award of an Architectural Technicians certificate to students who have attended approved courses and passed the appropriate examinations of the College or the examining body.

1.2 The course is intended to prepare the student for occupation in industry at Architectural Technician or Architectural Assistant level.

1.3 The course will be provided on a full time basis as set out in 1.4 below including two periods of Industrial Training for the purpose of gaining practical experience either in the college or in suitable professional or industrial business.

1.4

PART I TERM 1 14 WEEKS	PART I TERM 2 14 WEEKS	PART I TERM 3 14 WEEKS
SEPTEMBER - DECEMBER	JANUARY - APRIL	MAY - JUNE PART I EXAM
INDUSTRIAL TRAINING	PART II TERM 1 14 WEEKS	TERM 2 14 WEEKS
SEPTEMBER - DECEMBER	JANUARY - APRIL	MAY - JUNE
PART II TERM 3 14 WEEKS	INDUSTRIAL TRAINING	PART III TERM 1 14 WEEKS
SEPTEMBER - DECEMBER PART II EXAM 1	JANUARY - APRIL	MAY - JUNE
PART III TERM 2 14 WEEKS	PART III TERM 3 14 WEEKS	PART III TERM 4 14 WEEKS
SEPTEMBER - DECEMBER	JANUARY - APRIL	MAY - JULY PART III EXAM

THE AIMS OF THE COURSE

2.1 The aim of the course is to provide staff suitable for employment in Architects offices and Departments who should work under professional Architect should be competent in the following matters:

1. Site investigation.
2. Levelling and site survey.
3. Simple planning: the application of Building Regulations to simple problems of layout.
4. Site layouts of buildings and the important of Town Planning.
5. Town planning as a need.
6. Layout of drainage of single buildings and housing developments.
7. Sanitation, refuse disposal and hygene.
8. Natural science; lighting, sound, thermal insulation and their application to buildings.
9. Preparation of Design Drawings involving Plan, Section Elevation and perspective.
10. Development of working Drawings from Design Drawings.
11. Requirements of Building contract and contract law.
12. Interpretation of the Building contract and contract law.
13. Preparation of Drawings for Sub-contractors and obtaining estimates.
14. Preparation Electrical, Plumbing and service layout drawings.
15. The behaviour of materials in natural circumstances.
16. The preparation of simple calculations for structural members.
17. Methods of drawing identification, filing and referencing.
18. Preparation of cataloging of information on building components and methods.
19. The interpretation of B.S.S. and C of P.
20. Site supervision: Preparation of reports, site inspections relationships between contract or and Cl of works Dayworks, how to conduct site meetings.
21. Methods of drawing document reproduction.
22. Office procedure: Job management from Client's instructions to Final Accounts.
23. Job Management: Instructing specialists.
    Structural Engineers
    Services Engineers
    Understanding their drawings

		Q.S., quantities and specifications.
24.	Programming	Appreciation of Bar Charts and CPM.

COURSE OF STUDY

3.1 The course will be divided into the following parts as illustrated in 1.4:

(A) PART I - 3 terms up to Part I Examination which will be conducted within the college.

(B) INDUSTRIAL TRAINING - A period of 4 months to be spent obtaining industrial experience.

(C) PART II - 3 terms up to a Part II Examination to be conducted by the Examinations Council, and the issue of Part II Certificate to successful candidates.

(D) INDUSTRIAL TRAINING - A further period of 4 months to be spent in industry.

(E) PART III - 4 terms up to a Part III Examination to be conducted by the Examinations Council and the issue of a certificate to successful candidates.

3.2 A special aspect of the course will be the production of each student of a Portfolio of his work in Draughtsmanship which will be particularly related to the production of working drawings and sketch design drawings of a suitable standard.

3.3 The subjects to be included in the syllabus are:

1. Building construction and Public Works.
2. Technical Drawing
3. Mathematics
4. English and General Studies
5. Surveying
6. Building Science
7. Practical Workshop Experience
8. Structures
9. Building Contract and Office Administration
10. Building Regulations
11. Specification and Quantities.

12. Portfolio and Drawing Office Practice.

13. Materials of construction.

3.4 The number of hours of tuition will be based on 30 hours per week minimum, with each term to be a minimum of 14 weeks.

ALLOCATION OF TIME

SUBJECT	HOURS PER WEEK										
	PART I			PART II			PART III				
Building construction and Public Works	6	6	6	4	4	4	6	6	6	6	156
Technical Drawing	4	4	4	4	4	4	–	–	–	–	336
Mathematics	2	2	2	4	4	4	4	4	4	4	476
English & General Studies	2	2	2	–	–	–	–	–	–	–	84
Surveying	4	4	4	4	4	4	–	–	–	–	336
Building Science	4	4	4	2	2	2	2	2	2	2	364
Practical Workshop Experience	4	4	4	4	4	4	–	–	–	–	336
Structures	–	–	–	2	2	2	2	2	2	2	196
Building contract and office administration	–	–	–	–	–	–	4	4	4	4	224
Building Regulations	–	–	–	–	–	–	2	2	2	2	112
Specification and quantities	–	–	–	–	–	–	4	4	4	4	224
Portfolio and Drawing Office Practice	–	–	–	2	2	2	4	4	4	4	294
Materials of Construct Construction	4	4	4	4	4	4	2	2	2	2	448
	30	30	30	30	30	30	30	30	30	30	4200

ENTRY TO COURSE

4.1 Students entering the course will be expected to have the following qualifications:

Credit passes in the East African Examinations Council 'O' Level Examinations in:

(i) English

(ii) Mathematics

and one of the following

(i) Chemistry and Physics

or (ii) Physical Science

or (iii) Science for Technical Students.

Alternatively a student must have a suitable equivalent standard of education and must satisfy the college that he is capable of following the course without difficulty.

EXAMINATIONS

5.1 Examinations will be held as follows:-

At the end of Part I - Examination by College

At the end of Part II - Examination by East African Examinations Council

At the end of Part III - Examination by East African Examinations Council

5.2 Subjects to be examined at each phase.

Part I	Examination	Duration in Hrs.
	Building Construction and Service	3
	Technical Drawing	3
	Mathematics	3
	Surveying	3
	Materials of Construction	3
	Building Science	3

	Examination	Duration in Hrs.
Part II	Building Construction and Services	3
	Mathematics	3
	Materials of Construction	3
	Surveying	3
	Building Science	3
	Structures	3
	Practical Workshop	3
	Building Construction, Public Works and Services Paper I	3
	Building Construction, Public Works and Services Paper II	3
Part III	Building Contract and Administration	3
	Mathematics	3
	Materials of construction	3
	Building Science	3
	Specification, Quantities and Building Regulations	3

5.3 A student will be permitted to sit the examinations at the various Phases subject to the following conditions being complied with.

Part I - at the discretion of the College.

Part II - having achieved 75% attendance in Part I and II having having successfully passed Part I
having achieved a successful standard in protfolio work

Part III - having achieved 75% attendance in Part III
having successfully passed Part II examination
having achieved a successful standard in Portfolio work

5.4 Portfolio Work forms part of the examination at Part II and Part III as follows:

(a) The student must achieve a satisfactory standard which will be set and assessed by the College.

(b) The mark for Portfolio work will be on the basis of:

30% at Part II

70% at Part III

Total Mark 100%

5.5 Resisitting all or part of the examinations will be on the following basis:

Part I (a) A candidate may sit not more than two papers at a special examination set by the College.

(b) A candidate may repeat the whole course and resit the examination once only as a full-time student.

(c) Resit not more than two papers at the next ordinary examination without attending the course full-time.

Part II (a) A candidate may resit not more than one paper alone at the next ordinary examination on one occasion only.

(b) A candidate may resit the whole examination if he fails in more than one paper on the next normal examination on one occasion only, whether attending the course as a full-time student or not. The Portfolio mark may be taken forward to this one examination resit only.

Part III (a) A candidate may resit not more than one paper alone at the next ordinary examination on one occasion only.

(b) A candidate may resit the whole examination if he fails in more than one paper on the next normal examination on one occasion only, whether attending the course as a full-time student or not. The Portfolio mark may be taken forward to this one examination resit only.

5.6 The examinations will be set and answered in English, but examiners will not be required to assess the standard of English used by candidates. Students will be required to attend classes in English and General Studies during Phases I and the College will be required to assess the students performance in these subjects.

5.7 Records of marks awarded for classwork, laboratory work, practical work and portfolio work shall be kept by the College on the appropriate forms. All portfolio work shall be retained by the College in its original form and be available for any subsequent future reference.

BUILDING CONSTRUCTION

The function of the Architectural Technician is to be able to produce working drawings of all types of buildings from simple single-storey load-bearing structures to large buildings of multi-storey construction under qualified supervision. The principles of construction must be thoroughly understood and the course can be conveniently divided into the 3 parts.

Part I: Simple single storey framed and load-bearing structures.

Part II: Larger more complex buildings up to 4 storeys with basements.

Part III: Multi-storey structures with more complex foundation and basement construction.

Each part should deal with much the same aspects of construction as any other but with a gradual introduction of more detailed solutions as the problems are made more complicated by the wider use of technology. When eventually the student joins a professional office he will continue to learn as he meets with practical problems. Project work should be introduced in Part II and Part III, the student being given drawings of buildings from which suitable details of the various parts of theconstruction can be developed. Alternatively research projects can be given requiring investigation into the general aspects of constructional elements.

Particularly related to Building Construction are the following topics, and the relationship should be emphasised:

1. Science of Materials
2. Environmental Science
3. Applied Materials and Concrete Technology
4. Services
5. Simple Structural Theory
6. Technical Drawing

All construction must be referred back at all times to the Building Code of Regulations, and where applicable to British Standard Specifications and Codes of Practice. All students must have a copy of the Building Code and be required constantly to interpret these.

Site visits to works in progress should be frequently made to amplify aspects of the theoretic studies.

BUILDING CONSTRUCTION PART I

THE STRUCTURE

An explanation of the structural parts of simple load-bearing Construction:

The Foundation

The load-bearing wall

The suspended floor

The floor laid on the ground

The Roof

The difference between the load-bearing construction in single-storey buildings in respect to:

The foundations

The wall and frame

The roof and rooftruss

THE FUNCTION

The purpose of construction in relation to weather and environment.

THE REGULATIONS

The way buildings are controlled in respect to their planning and construction by official regulations.

FOUNDATIONS

Definition, purpose and form of simple foundations.

Building Code requirements and soil bearing.

Setting out and excavation of strip foundation and column bases.

Excavation and timbering to simple trenches in various soils.

Stepped foundations. Simple raft foundation.

WALLS : GENERAL : BELOW GROUND

Bricks and blocks in the construction of walls.

Relative sizes and materials.

The bonding of bricks and blocks, the formation of angles, piers, openings.

Load-bearing and non-load bearing construction with reference to the Building Code

Stone in walling: Single thickness load-bearing and in composite construction with block or brick.

Materials in the construction of walls below ground, and the transfer of loads to foundation. The strength and thickness of walls.

CONSTRUCTION ADJACENT TO THE GROUND

The removal of vegetable soil and black cotton soil.

The relationship of walls and floors at ground level with respect to damp proofing, termite protection and other insects.

Materials used for d.p.m. and d.p.c. and the requirements of the Building Code.

Solid concrete floor construction and hardcore beds. Backfilling.

Suspended Timber ground floor construction; the problems of adequate ventilation, insect infestation and damp.

Provision for introducing services (water, electricity) into building.

Steel columns; typical details of connection to base.

WALLS ABOVE GROUND

The appearance of different walling materials externally and the methods of bonding and pointing.

The construction of openings and forming reveals.

Lintols and arches.

Fireplace construction at ground floor and fires.

The effect of bearing floors and roof on walls.

Partition walls in masonry at ground and first floors.

Lengths of wall and provision of buttressing as building Code.

Gable and walls.

Steel columns: various methods of infill and cladding in masonry and cladding materials.

SUSPENDED FLOORS AT FIRST FLOOR LEVEL

Timber suspended floors: loadings, spacing and spans of joists, strutting, and bearing and fixing, flooring in t and g, chipboard, plywood, etc and provision of ceilings.

In-situ reinforced concrete floors, solid or hollow construction.

Formation of openings and layout of simple reinforcement.

Simple spans or continuous over support such as a beam or wall.

Simple formwork to in-situ r.c. floor.

ROOFS

Timber roof construction; the principles of purlin roofs and simple roof trusses or trussed rafters. The use of sheet and tile finishes and the effect on choice of timber roof construction.

Methods of constructing timber roof trusses, sizing of purlins and common rafters. Gable ends and hipped ends compared.

Steel roof construction; detailing of simple roof truss, purlin layout and connection to column.

Roof tiling and sheeting details; eaves guttering and weathering at abuttments. Bat-proofing and thermal insulation.

Timber flat roof construction, sizes of joists and spacing and provision of falls for built-up felt roofing. Details at eaves and abuttments, penetration through flat roofs.

In-situ concrete flat roof construction; the provision of falls and insulation. Finishing with built-up felt and asphalt waterproofing.

STAIRS

Principles and rules governing stair construction and design.

The construction of a straight flight of stairs for domestic use in timber and reinforced concrete.

Simple handrail and balustrades.

Simple formwork to insitu r.c. stairs.

DOORS

Timber doors for internal and external use including frames and linings. Solid flush doors, ledged and braced doors, simple glazed doors.

Fixing of frames, linings and architraves in plaster walls.

Details of head, jamb and cills to external doors.

WINDOWS

The regulations governing light and ventilation in buildings.

Typical detailing of simple timber and steel casement and fixing in openings, various cill detailing.

Clear and obscure glazing and fixing by putty or bead.

FINISHES

Simple floor finishes; screeds, granolithic flooring, wood block and p.v.c. tile flooring, methods of laying.

Plastering to internal walls and ceilings.

Painting of metal and wood and plaster using oil and emulsion paints.

SERVICES

The arrangement of water supply and plumbing to typical sanitary fittings in domestic buildings; simple hot water supply. Basic principles of waste and soil drainage. Building Code requirements.

Simple drainage and connecting to main sewer.

Basic electrical installations. Definitions of terms used.

Electrical generation and distribution briefly de-cribed.

BUILDING CONSTRUCTION PART II

THE STRUCTURE

The principle of the frame as applied to building of three to four storeys high.

The load-bearing cross-wall method of construction.

The idea of this lightweight wall infill or panel.

FOUNDATIONS

Investigation of soils, bearing capacity and shear.

Trial holes and borings.

Foundation size in relationship to loading and bearing capacity.

Reinforced concrete foundations - bases to r.c. frames, continuous bases, rafts.

R. c. foundations as part of basement construction: r.c. rafts and retaining walls.

Excavation of bases, rafts and basements in various types of ground: support of adjoining buildings during excavation: underpinning.

Timbering to excavations and shoring to adjoining buildings.

Problems of water in basement excavation: site dewatering and dampproofing of basement: water pressure and water table. Water removal during building operations.

Typical mechanical plant used in excavations.

Pile foundations using precast and in-situ methods of forming driven and bored, end-bearing and friction piles.

WALL

Load-bearing cross-wall construction: limitations and uses.

In-situ r.c. wall construction and formwork.

Panel walls as infill to r.c. and steel frames using simple masonry construction.

FRAMES

Reinforced concrete framed construction: economical layout for small low-rise structures using in-situ methods: frame and slab continuity and stability.

Steel construction for similar framed buildings.

Steel portal frames and trusses for wider span single-storey buildings; the use of casterllated beams and lattice joists in light-weight construction.

Precast concrete portal frames in reinforced and prestressed concrete. Typical spacing and spans.

CLADDING

Claddings to single-storey industrial buildings to roofs and walls: sheet materials, deckings, insulated construction: the provision of glazing in external walls and roofs.

SUSPENDED FLOORS

The construction of single, double and triple floors in larger buildings using combinations of steel and concrete.

In-situ reinforced concrete T-beam, waffle and flat-plate floors principles.

Precast concrete floors using various established methods.

FORMWORK

Formwork methods in the construction of floors, beams, upstands and walls. Principles of construction, placing of reinforcement, striking, materials and safety precautions.

ROOFS

Revision of built-up roofing and asphalt.

The use of corrugated materials: galvanised iron, asbestos-cement, aluminium.

Various forms of light-weight decking.

Roof lights, domes, lantern lights, dormer windows, patent glazing.

Trimming for openings, upstands, weathering at penetrations.

Further detailing of abuttments, gutters, rainwater pipes, parapets and overhangs.

STAIRS

Revision of principles of staircase design: investigation of Building Code and Sixth Schedule.

Stair-case arrangements, open-well, dog leg, geometrical.

In situ reinforced concrete construction; methods of support: relationship to r.c. frame and floors.

Further balustrade and handrail details, finishes to treads and risers, including non-slip.

DOORS

Half-hour and one-hour fire resisting door and frame construction: fire resisting glazing, self-closing apparatus and ironmongery.

Larger hardwood framed and glazed entrance doors and sidelights; suitable ironmongery.

Top-hung and bottom-rolling straight sliding doors and partitions.

WINDOWS

Detailing of pivotting and sliding windows in timber and aluminium various cill details.

Various types of glazing sizes and thicknesses.

PARTITIONS AND CEILINGS

Lightweight partitions in timber and metal.

The principles of demountable partitions: fire-resistance and sound insulation.

The principles of suspended ceilings using timber and metal suspension, plaster on expanded metal or tiles in T-angle suspension.

FINISHES

Various types of plaster and renderings applied to various types of backings; suction and adhesion.

The use of metal lathing.

Wall boards as finishes: timber, soft board.

Wall tiling and wall mosaics.

Floor finishes: tarrazzo, claytiles, mosaics.

Further studies of painting finishes, cement paints, acrylics, enamels, chlorinated rubber, bitumen.

Plastics and synthetics as adhesives and sealants.

SERVICES

Larger water storage problems. Water tanks: the weight to be supported by structure.

Problems of distribution in multi-occupations.

Layout of sanitary installations of economic water supply and internal drainage.

The function of automatic flushing cisterns: urinal installations in public buildings. Layout of public lavatories.

Simple mechanical ventilation to internal w.c. 's.

Various methods of providing instantaneous hot water.

Electrical installations: single and 3-phase: circuit layouts.

EXTERNAL WORKS

The construction of tarmacadom and concrete drives, paths, estate roads and parking areas.

Surface water drainage.

Gates and fence wall in metal and masonry.

BUILT-IN FURNITURE AND FITTINGS

The design and detailing of kitchen units, wardrobes and cupboards; timber framing, blockboard, plywood, chipboard, painted and plastics finishes. Ironmongery.

BUILDING CONSTRUCTION PART III

THE STRUCTURE

Multi-storey framed construction using suspended, cantilevered and propped cantiliver constructions.

Wide span framed construction for single-storey buildings using shell concrete, complex steelgirder construction and space frames.

The principles of stability in multi-storey and single storey framed structures.

Control of various forms of movement: thermal, wind forces, settlement.

ENVIRONMENTAL FACTORS

The orientation of buildings in tropical locations to reduce glare and heat-gain.

Projections, overhangs and sun-breakers.

FOUNDATIONS

Further investigations of shear and pressure due to large buildings on soils of various types.

Diaphragm walls and retaining walls to deep basements.

The effect of reducing the over-burden on foundation design.

The design of foundations adjacent to other high buildings: trapezoidal and cantilever foundations.

Further work on piling: clusters, pile caps, ground beams.

Sub-soil drainage to reduce or divert water in foundations.

Designing for subsidence and earth movement.

Control of stresses in foundations: hinged construction.

WALLS

Cladding of multi-storey framed structures: various precast and in-situ panels, storey grames, methods of fixing to framework, methods of casting, methods of hoising.

Insulated composite preformed panels in metal and concrete for cladding industrial buildings.

FRAMES

Continued investigation of all forms of r.c. framed construction in multi-sprey building.

Wide span single-storey portal frames in laminated timber. Hinged frames.

Space frames and grid structures.

Warren girders in wide-span construction

ENVIRONMENTAL CONSTRUCTION

Detailing of walls, roofs and partitions to provide thermal and sound insulation in various conditions and extremes.

Special provisions for ventilation and air--onditioning in all types of buildings from natural ventilation in the siting of domestic buildings to air-conditioning and refrigeration.

SYSTEM BUILDING AND PREFABRICATION

The investigation of all forms of buildings prefabrication from simple single components to complete buildings.

FORMWORK

The use of form-work systems: climbing and moving wall forms, table forms.

STAIRS

Composite construction using in-situ and precast units, concrete, timber and steel, cantilevered treads, complete precast stair flights.

SERVICES IN MULTI-STOREY BUILDINGS

The provision of space for installations.

Methods of ducting and concealing services within ceilings.

Liaison between architect and services engineers in Heating, Air Conditioning and Lift installations.

Lighting conductors.

Electrical installations: regulations: preparation of drawings.

Fire fighting equipment.

MAINTENANCE AND REPAIR OF BUILDINGS

Maintenance, repair and alteration of existing property. Precautions when altering existing construction. Temporary support, needling and shoring. Various methods of underpinning load-bearing and frame structures. Schedules of repair and maintenance.

PUBLIC WORKS

Estate layout for domestic housing and similar group development.

Liaison with Public Utilities to determine feasibility of developments.

Estate roads, lighting, refuse collection.

Location of services above and below ground.

MATHEMATICS

The aim of this syllabus is to provide instruction in the use of mathematical methods and principles which will make the student capable of dealing with allied problems in all other subjects. The mathematics should be totally relevant at all stages and typical constructional problems should be used to demonstrate theory.

Where necessary the mathematics required in other subjects should be taught in advance. The subjects related to the mathematics subject are Geometry, Science, Material and Environmental Science, Services, Structures, Concrete Technology, Surveying, Administration. S.I. units are to be used.

MATHEMATICS PART I

Arithmetic:	Revision of length area and volume calculations with particular emphasis on neat presentation and the necessity to show all the working for subsequent checking.
Ratio and Proporation:	Percentages and simple interest.
Pythagoras Theorem:	Perimeters and areas of regular and irregular shapes.

Volumes and surface areas of regular figures, prisms and cylinders.

Measurement of angles: the compass: length of arc: area of sector and segment of circle.

The use of logarithms and slide rules.

Algebra:	Albebraic expressions and processes: use of brakets.
Simple formulate:	Transposition and substitution.
Solutions of equations:	Graphical representation of functions and equations.

Law of indices: Graphs: linear function.

Determination of straight line law from experimental data.

Simple use of logarithms in evaluation of numbers with negative and fractional indices.

Trigonometry:	Sine, cosine and tangent and graphs of same.

Application to solution of right angled triangles.

Relations between trignometrical ratios.

Determination by calculation of areas of triangles.

MATHEMATICS PART II

Forces: Definition of forces: types of force met with in structural calculations.

Units for measuring gravitational forces.

Co-planar systems of forces: non-current and non-concurrent.

Graphical representation of a force: resultant of any number of concurrent forces.

Calculation methods of forces.

Resolution of forces using rectangular components.

Horizontal and vertical components.

Concurrent force systems reduced to rectangular components.

Resultant of concurrent system of forces.

Graphical Laws of Equilibrium: Bow's Notations.

Triangle of forces: experimental verification.

Three forces in equilibrium: relating theorem.

Polygon of forces.

Levers: Principles of levers: experimental verification calculation of beam support reactions.

Theory of moments of resultant forces.

Couples: Like and unlike parallel force systems.

Definition of couples: Properties and moments of a couple: condition or equilibrium for concurrent and non-concurrent forces.

Centre of Gravity: Definition: calculations of centre of gravity involving two or more equal or unequal bodies.

Centroids of composite bodies and plane axial figures.

Moment of Intertia and Radius of Gyration.

MATHEMATICS PART III

Calculus: Differenctiation of standard algebraic functions from first principles, and algebraic, trignometric, exponential and logorithmic functions.

Differentiation of inverse trignometric and implicit functions.

Application of differentiation to rate of change. Velocity, acceleration.

Maxima and minima, approximate solution of equation, radius of curvature at a point. Integration as a reverse of differentiation. Standard forms of integration. Integration by resolving into partial fractions. Integration by parts. Application of integration to simple area and volume, length of arc, centroid of area, centroid of solids and moment of inertia.

Differential equations of the first order and degree. Linear - differential equations of the second order with constant coefficients. General solution and particular solution.

Complex numbers. Properties and manipulation of complex numbers. The Argand diagrams. Euler's equation and its application. Cube root of unity. Application of complex numbers.

Introduction of matrices of second and third order. Determinants. Application of matrices in solving simultaneous equations with two and three unknowns.

Introduction to elementary probability and statistics.

Normal frequency distribution and calculation of means and standard deviations.

STRUCTURES

The aim of the syllabus is to provide a basic understanding of the structural problems frequently met with in Architectural design and construction, so that the students will be able to appreciate the structural limitations of Architecture.

Complicated calculations are to be avoided, but elementary designs should be attempted as part of the course work.

Theory and practice should be adequately supported by experimental verification work in the laboratory.

Reference should be made continually to relevant copies of Practice and Building Regulations.

STRUCTURES PORT I

Mechanics:

Introduction for forces: balanced and unbalanced forces. Experiments to demonstrate equilibrium: action and reaction.

Concurrent and coplanar forces: non-concurrent coplanar forces.

Parallel forces: moments, torque and couples; application to structural members: experimental examples.

Reactions of the supports of a loaded beam: experimental proofs.

Understanding of Newtons 1st, 2nd and 3rd Laws.

Basic Structures:

Force diagrams for roof trusses and girders: force and stress in the structural members: regulation and composition of forces.

Simple calculations and design methods for frames.

Properties of Sections:

Moment of Inertia, section modulus, Neutral axis and plane symmetry, centroids, Radius of Gyration.

Parallel axis theorem.

Stress and Strain:

Definition of stress and strain, elasticity and yield point.

Proof stress, modulus of Elasticity, rigidity and bulk. Hookes Law. Types of failure of materials; working and ultimate stress: factor of safety.

Bending Moment and Shear Force:

Simple definitions of bending moments and shear force. Graphical and analytical determinations for cantilevers and simple supported beams: uniform and point loads: bending moment diagrams by link Polygon methods.

Design of Beams and Slabs:

Theory of simple bending slope and deflection relationship between load, shear, bending moments, slope and deflection distribution of shear stress. Reinforcement: areas and distribution.

Design of Foundations:

Bearing pressures and foundations areas: eccentric loading: continuous, trapezoidal and cantilever foundations; stress distribution.

Design of Columns:

Axial loads on short columns: slenderness ratio and working stresses.

Design on Walls:

Stability of retaining walls: load-bearing walls and the Building Code: CP III.

Design of Roof Trusses:

Force diagrams for roof trusses: force and stress in numbers: regulation and composition of forces: simple calculation and design methods for frames.

Design on Structural Steel:

Calculation of rivets and bolts use of steel tables: selection of members.

Timber:

Stress grading: design of timber members in flat roofs and floors: timber connectors.

Pressure: elementary treatment of wind, water and earth pressures on structures.

BUILDING CONTRACT AND OFFICE ADMINISTRATION

This syllabus is intended to introduce the student to the role of the architect in organising the production of drawings and administration of building contracts from the receipt of clients instructions to the settlement of the final account.

The Building Contract as the guiding principles of the running of Building works should be fully understood.

Visits to Architect's offices where possible and to sites to observe practical administration are most important.

The people involved in a building from the first need to drawing state, from tender to completion.

The Architect:	his role and responsibility.
The Client:	individual or group.
The Contractor:	the intentions and responsibilities.

The Quantity Surveyor: The Structural Engineer

The Local Authority.

The various types of Building Contracts and Articles of Agreement e.g. with and without Quantities.

The various ways that tenders can be presented and financial control of work be agreed, such as Lump Sum, Cost Plus, Package Deal, etc.

Preparation of Sketch Designs from Clients instruction: Questions to ask Client.

Preparation of Working Drawings: need to comply with Building Code: use of Regulations and Codes of Practice. Submission of drawings to Local Authority for approval. proformas used.

Liaison with specialist Engineers and Quantity Surveyor: Cost Control.

The Drawings and Specifications or Bills of Quantity required for Tendering Obtaining tenders: Forms of Tender and other Documents.

Dealing with Tenders: Preparing programmes

Placing Orders - preparation of Building Contract for signatures.

The Building Contract; the clauses in detail.

Site Administration and site visits.

Site instructions: Architect and Clerk of Works, Variations, Valuations, Certificates, dayworks.

The role of the Clerk of the Works: control of standards: testing materials.

The conducting of Site meetings; Preparation of minutes and site reports.

Various methods of presenting programmes: Bar charts, Critical Path Method, Histograms, Graphs, Precedence Diagrams, Flow Charts.

The responsibility of the Architect for the design and construction of the whole building: schedules of Defects and Latent defects: the importance of the Final Certificate: Arbitation.

Architects office procedure: the personnel required: office layout.

Drawing numbering systems and filing.

Office filing systems: Filing of correspondence and technical material.

Business machines and methods.

The preparation of Final Accounts.

Cost analysis and recording and use

Computerised systems.

Builders accounting methods: the double entry system.

SPECIFICATION OF QUANTITIES:

As a basic for study it is recommended that the student is provided with typical specification documents and Bills of Quantity and a set of related drawings.

Later the student should be required to produce his own specifications from drawings.

Quantities will be studied from the point of view of the Architect who needs to be able to understand only the methods of interpreting the Bill contents.

SPECIFICATION:

Introduction to the Specification as a document providing full information on all aspects of Building Work.

The parts of Specification: The conditions the preambles and the specificatin of the work.

Specifications for Sub-contracts and specialist work.

Examples of conditions to typical Building Contracts.

Examples of Preambles to the various trades.

Examples of Specification items.

Methods of constructing preambles and specification clauses.

The use of Schedules.

Relationship to Working Drawings: Specification as used as descriptions of Drawings.

Typical Work Headings as taken from Standard Method of Measurement.

QUANTITIES

Introduction to the Bill of Quantities and the Standard Method of Measurement.

The function of the Quantity Surveyor and his relationship to the Architect and the client.

The units used: metres run, square, cube and number.

How the quantities are taken off the drawings: examples of measurement of works in the various ways of including their work in the Bills of Quantity.

Prime cost and provisional sums.

Analysis of items occuring in theBill of Quantities.

The methods employed by quantity surveyors in producing the Bills; taking off, billing, abstracting, cut and shuffles, etc.

Measured rates: how they are established, revised and stored.

Cost control from Bills of Quantity.

Preliminary estimates of cost: approximate methods based on unit area, volume, etc.

Omissions and additions: Variations: Day works.

Pricing Variations: spot items.

PRACTICAL WORKSHOP EXPERIENCE

Masonry, Plumbing and Carpentry and Joinery are dealt with as fully practical subjects with the student handling tools and materials as much as possible.

The syllabus will be related to the theoretic aspects covered in the Construction syllabus and typical work drawings and services drawings should be available for direct reference.

MASONRY

Introduction to the types of materials used in walling, bricks, concrete blocks, stone.

Dry bonding in various bonds suitable to material and use.

Special problems at internal and external angles and stopped ends.

Junctions between various materials: -lock bonding and other methods.

Tools used in masonry work: their use and maintenance.

Laying walling materials using mortar: placing materials near the work.

Preparation of mortar by hand and machine.

Setting out for excavation, setting up profiles, transferring the datum level.

Setting out walls on a concrete foundation: bonding straight lengths of wall: bonding at angles, junctions and openings.

Laying dampproof membranes.

Fixing of door and window frames and linings.

Formwork for in-situ lintols: placing reinforcement.

Casting concrete: striking times.

Precasing lintols and fixing to openings.

Bonding and fixing timber roofs and wall plates to masonry.

Jointing and pointing to new and old work.

Wall plastering.

Floor screeds.

Scaffolding and working platforms.

PLUMBING

Pipework: the various materials typically used in plumbing pipes in buildings: copper, galvanised iron, plastics, mild steel, castiron.

The use and limitations of the various materials: costs.

Jointing methods for various pipes, including jointing to earthware.

Cutting pipes and making threads.

Typical traps for use with waste systems.

Sanitary fittings; fitting of traps and wastes and taps.

Function of syphions and ball valves.

Use of tools for cutting, welding, soldering, brazing, drilling and tapping.

External plumbing; the various materials used in flashings and weathering, lead, zinc, aluminium bituminous felt, plastics.

The cutting and dressing of the various materials.

Rainwater gutters and downpipes.

CARPENTRY AND JOINERY

Introduction to the tools and equipment including care and maintenance, tool sharpening and safe practice.

Softwood and hardwood: the use and selection.

Jointing; halving: mortice and tenon, devetail, tusk tenon.

Use of dowels, nails, screws, dogs and adhesives in joining timber.

Special materials: chipboard, plywood, hardboard, block board: typical use in joinery: methods of joining and fixing.

Carcassing timber: roof truss construction using timber connectors.

Trimmingopenings: strutting: splicing: birdsmouth.

Formwork and moulds: the use of wedges.

Fixing architraves, skirtings and mouldings.

Hanging doors and windows: fixing ironmongery.

Preparation of woodwork for painting and polishing.

Fixing of sheet plastics.

Use of power tools.

Introduction to function of various woodworking machines.

Workshop procedure: full size setting out from Architects.

Working drawings: preparation of cutting lists.

Problems of installation on site.

ENGLISH AND GENERAL STUDIES

The first part of the syllabus should concentrate on the use of English developing towards the idea of technical language. This will enable the student to apply this in all the other subject.

The second part the background to building and the historic and social implications.

ENGLISH: The use of language to enable communications to be made simple: logical thinking: accurate speech, meaning and writing, report writing, simple logical statements compared with narrative writing.

Effective speech and effective writing using the least number of carefully chosen words: the layout of sentences in specification writing.

Presenting ideas in logical sequence: practice in analysing situations and reporting effectively on them.

Review of common pitfalls in English composition, sentence construction and word order.

Practice in writing brief descriptions, letters and reports in a prescribed number of words: technical terms and expressions used in the construction industry.

Preparation of reports on suitable subjects such as:

- Local building history and customs;
- Economics of machinery versus manual labour;
- Local trades union growth;
- Time and motion studies;
- Working techniques in the construction industry;
- Town planning and rural development.
- Low-cost housing.

General Studies: Examples of notable building structures of earlier ages and cultures (e.g. Aztec, Assyrian, Chinese, Burmese) including national and world-wide examples.

Historic background to modern architecture: notable examples of town planning particularly in developing countries: the problems of population in housing.

The influence of culture, geographical location, climate, availability of materials and technology on building design and construction.

Need for planning based on the requirements and often conflicting demands of industry, agriculture, living accommodation and population movement.

Sanitation related health and population density.

The training of Architects and their role in Society: the responsibility of the architect to control and interpret the needs of the community in design and planning of buildings.

The use of labour in the construction industry and the contunuing development of mechanical equipment.

The Trade Unions in the Construction Industry and the relationship to client and Architect.

BUILDING SCIENCE

The syllabus is intended to deal with the scientific theories behind the way in which building materials to light, heat and sound, how water flows and how pressure occurs in materials among other things.

Where possible models and simple machines together with standard Science Laboratory techniques should be used to demonstrate principles.

There could also be a relationship with the syllabus "Materials of Constructions".

HEAT:

The nature of heat: conduction, convection and radiation.

Thermal conductivity of building materials, Radiation.

Prevost's theory of exchanges. Stefan's law.

Change of state. Fusion, Vaporisation. Latent Heat.

Heat and work: The joule/watt second. Specific heat.

Heat insulation and heat transfer in building construction.

Conductivity, resistivity. "U" values. Solar heat gain.

Building orientation and solar movement. "Greenhouse effect".

HUMIDITY:

Hygrometry, relative humidity. How to find it. Instruments used.

Effect on human comfort: problems of controlling condensation in buildings and reasons for.

VENTILATION

Air movement: global and local: influence of temperature: stack effect; natural and artificial air movement.

Natural ventilation: full air conditioning (Principles)

HUMAN COMFORT:

Combination of heat, humidity and ventilation to achieve desirable standards: body adjustments and limitations.

BUILDING DESIGN FOR CONTROL

Building layout and orientation: construction details for insulation and exclusion of sunlight.

Sources of heat within buildings: environmental design.

Total building design for optimum conditions.

LIGHT

Natural light: sunlight and daylight: nature and propogation: frequency: wavelength and spectrum.

Elementory photometry: illumination intensity: inverse square law. Lamberts cosine rule.

Rectiliniar intensity and lux: illumination, lux, brightness.

Daylighting: orientation: window size: shading calculations using various factors.

Use of protractors and nomograms: sun angles at various attlatitudes.

Principles of artifical lighting design: desired levels of illumination for various tasks: glare: Bodmin's ratio.

Artificial lighting related to environmental design.

Head output from fittings.

SOUND:

The properties and behaviour of soud: sound sources: frequency and wavelength: speed, wavelength and frequency.

Sound pressure and wavelength: sound pressure level and decibel scale.

Sound and distance: sound transmission in solid materials.

Diaphragm amplification: panel transmission.

Sound insulation: airborne and impact sound: methods of calculating sound intensity: methods of screen and insulating buildings: airborne and impact sound insulation within buildings: noise and inter-erence levels within rooms: machine vibration.

Acoustics: the Sabine method of calculating the reverberation times in rooms: absorption coefficients of materials: sound paths and reverberation.

ELECTRICITY

Ohm's Law: Series and parallel currents: polarity current flow. E.m.f. and P.d. Energy and power in simple circuits.

HYDRAULICS

Fluid motion: Bernoulli's theorem.

Discharge through oriffices and nozzles: venturimeter.

Flow in pipes.

Uniform open channel flow.

Distribution in pipes: pipe sizing.

Rainwater disposal: flow on roofs, in gutters and downpipes.

Hydrostatic pressure.

MACHINES

Simple principles of machines used in building.

Levers: wheels: friction: slopes: fans: the heat pump.

STRESS

How stress effects building materials: bending: shear.

Compression and tension. Wind pressure and suction.

CLIMATE

The study of climatic conditions in respect to rainfall, humidity, sunshine and their effect on building.

The main subdivisions in Kenya of the country according to location and climate e.g. Coastal, Highlands, Lake, etc.

Comparisons between buildings in various climates and the effect on form, method, orientation, etc.

MATERIALS OF CONSTRUCTION

This subject must be dealt with in a practical way almost as a laboratory subject. The students should be able to handle all the materials, to judge there texture, colour, density, etc. by visual examination.

All the materials should be subject to simple tests, and the appropriate test equipment should be in the same room as the sample materials.

Records should be made of test experiments and as far as possible, the students should carryout the tests undersupervision.

Reference to manufacturing processes need only be sketchy, sufficient to set the scene for discussion of material behaviour.

All the British Standards and Codes of Practice relevant to the materials should be available.

Site visits to see the materials being fixed should be organised.

The materials - most commonly used in building

Concrete:

the constituents of concrete: cement, sand and aggregates and water.

Why concrete is used so widely: its strength and limitations.

The way concrete is formed from the constituents: from batching through to final curing.

Types of sand aggregates and their properties and uses.

Simple tests for cement and aggregates.

Properties of concrete related to mixes, rations, aggregates.

Control of quality in concrete production and tests for strength, workability, etc.

Types of reinforcement commonly used in reinforced concrete.

Concrete products: blocks, tiles, etc.

Steel:

The formation of iron and various types of iron used in building: the production of steel, carbon content.

The properties of iron and steel.

Methods used in manufacture of steel sections, bars and components: heat treatments.

Properties: strength, thermal movement. durability, simple tests.

How steel is used in reinforced concrete.

Iron and steel components in building: galvanishing.

Stone:	The classification and formation of naturally occuring stones. Igneous, sedimentary, metamorphic.
	Properties useful in building construction: appearance durability. density, strength porosity, permeability, resistance to fire and water.
	Common uses: methods of treating for use in buildings.
Timber:	Softwood and hardwood: the characteristics: how the tree grows.
	Conversion from tree to building timber: sawing: seasoning.
	Howtimber is used: precautions against defects occuring: treatment: effects of damp etc. insect attack.
	Properties: moisture content: swelling and shrinkage: crushing and shear strength: simple tests.
	Selection for purpose: structural, decorative, various typical finishes: standard sizes and reduction due to planing.
	Further materials which are naturally - occuring and are used in buildings: importance of soils in load bearing conditions.
Clay:	Source of material and origin.
	Typical building components: bricks, tiles and blocks, pipes.
	Properties, porosity, strength, density, durability fire resistance etc.
Non-ferrous metals:	Aluminium, copper, lead, zinc.
	Sources of materials and typical used in building.
	Methods used in manufacturing components: casting, extruding.
	Properties: strength, ductility, thermal movement, durability and weathering.
	Surface coatings and anodising.
	Typical uses in building.
Plaster & Mortar	Materials used: lime, cement, sand, gypsum. Sources and methods used in plastering and blocklaying.

Chemical changes which make lime and gypsum useful in plasterin and rendering: ganging or mortar.

Application of plasters to various backgrounds: adjustment of mixes: bond and suction: control of shrinkage and expansion.

Workability in mortars, mix propertions, Hardening, durability.

Typical tests of lime and cement.

Soils:

Typical soil structure and the importance in building construction and foundations.

Composition: gravel, sand, silt, clay.

Properties: moisture content, strength, shear resistance.

Tests: particle size analysis, liquid, plastic and shrinkage limits, plasticity, etc.

Stability: methods of consolidation.

Prepared and Manufactured Materials

Building Boards:

Plywood, blockboard, chipboard and hardboard softboard, asbestos-cement, woodwool.

Methods of manufacture: properties: typical uses in building construction.

Bituminous Materials:

Sources of bitumen, tar and pitch manufacture of mastic asphalt.

Uses of bitumen and asphalt in building.

Physical properties and simple tests.

Butties, Mastics and Adhesives:

Adhesives: Typical materials: bitumen, rubber, butyl, resins.

Methods of use and properties.

Plastics:

Classifications: thermoplastic and themosetting.

Types: polymethyl methacrylate, polythene, polyvinyl, chloride, polystyrene, polyurethane, etc.

Composition: plasticisers, fillers, pigments.

Manufacture: powders, pellets, extrusion, injection, moulding casting and callendering.

Typical products: boards, pipes, foams, laminates.

Properties: strength, moisture, heat, fire resistance, durability, sunlight, chemicals.

Glass: The main constituents and manufacturing processes of cast, float, plate glass, etc.

Types of clear, obscure, antisum glasses.

Special applications: glass blocks, glass fibre insulation glass fibre resin (G.R.P.)

Paints: Typical constituents of varnish and paint; natural and synthetic.

Types: gloss and flat oil, distemper, emulsion, plastic, chlorinated rubber.

Painting systems: primers, undercoats, finishes.

Properties: resistance to weather, fire-retardant, intumescence, corrosion resistance.

Painting of various backgrounds.

Rubber: Sources: production and applications.

Typical properties.

TECHNICAL DRAWING

The syllabus begins with simple geometry which is intended to give experience in the handling of all the instruments which the student will eventually use in the Architect's Drawing Office. This leads up to the first attempts of working drawings.

The second part considers the problems of solids and again ends with the production of typical architectural drawings.

Initially drawing should be on cartridge paper, bit the techniques of drawing on tracing paper and the reproduction by printing should be used as much as possible. Other special materials such as linen (now mainly obsolete) and plastic drawing media should be introduced if thought appropriate.

In the later states of the course Technical Drawing will be part of the Construction, Portfolio and other subjects and the student will be expected to produce drawing work of a high standard.

TECHNICAL DRAWING PART I

Introduction to the use of all drawing instruments and materials such as tracing and cartridge paper. Paper sizes and how these relate to one another. S.I. Units.

How to draw lines of different weights using varying pencil grades.

Division of lines and lines of various angles to one another, using protractors and adjustable set squares.

Formation of all types of regular figures: triangles: rectangles, trapexium, etc. Bisecting angles using compasses.

Regular and irregular polygons and related circles.

Circles: arcs, tangets, chords, segments, etc.

Ellipses: methods of construction.

Simple lettering: construction of letters using instruments.

First angle projection: development of drawings to show all faces of simple 3 dimensional model.

Isometric projection of 3 diamensional model.

Exercises in free hand drawing.

Complete drawing to incorporate the geometric forms into a finished technical drawing, including lettering and dimensions, titles, etc.

TECHNICAL DRAWING PART II

Prisms, cones and pyramids: construction and pictoral presentation using isonometrics.

Development of cutting planes in cylinders cones and pyramids.

Intersections of regular figures and cylinders.

Loci: the paths of points: involute, cycloid, parabola and hyperbola etc.

Development of surface areas of solid figures.

Isometric projection of curved shapes.

Simple perspective: constructed and freehand.

Introduction to the basic principles in the preparation of working drawing: typical scales.

Setting out of drawings on standard sheets.

Simple building drawing to incorporate plans of foundation, ground and first floors and roof, elevations and sections.

Development of details of increasing scales up to full size.

Methods of presenting materials, layout of lettering, dimensioning of drawings.

Preparation of complete set of drawings from a suitable sketch design provided.

Preparation of measured drawings by surveying existing constructions.

Colouring of drawings: sciagraphy.

BUILDING REGULATIONS AND CODES OF PRACTICE

An essential port of all building design and construction is a proper understanding of the local Regulations which have to be applied. Within these regulations there is frequent reference to British Standards and Codes of Practice.

This syllabus is related to these controlling aspects.

The Building Code

The various parts of the Code should be read and discussed.

Interpretation of clauses should be related to diagrams and examples.

Metric equivalents should be calculated from those given in the Code where they have not been metricated.

During construction lectures the Building Code should always be hadn to relate the various clauses.

The Factories Act

Those aspects of the Act which relate to building, building sites and machines, such as safety, Health and Welfare should be fully explained and understood.

British Standard Specifications

The purpose of having standards and how they are arrived at.

Typical standards: cement and other basic materials; tests for fire and similar: sanitary fittings.

Introduction to the Handbook issued by the British Standards Institution.

British Standard Codes of Practice

The object of the Codes and their relationship to B.S. specifications.

A few typical examples of Codes to show how they are constructed.

Reference to the Building Code and the Codes of Practice included in it.

Building Research Digests

The function of the Building Research Establishment.

How the Digests compared with British Standards and Codes of Practice.

Typical examples of Digests.

Kenya Bureau of Standards

Information on the work and development of the Bureau.

DRAWING OFFICE PRACTICE AND PORTFOLIO WORK

As the student becomes more proficient in drawing through the Technical Drawing syllabus, he should be introduced to Drawing Office Practice, where in he should learn about keeping records of typical information which is constantly and repeatedly used.

DRAWING OFFICE PRACTICE & PORTFOLIO WORK

He should be encouraged to acquire files of technical information from official publications and manufacturers handouts and catologue this according to a suitable system.

The method of preparing full sets of drawings and careful systems of cross-reference should be explained.

At all states finished work should be carefully stored to make up at the end of Parts II & III into Portfolios of work.

These Portfolios are to be submitted at the appropriate times for assessment of the students progress.

The whole syllabus should be of a practical nature providing conditions for the student to achieve a high standard of work.

DRAWING OFFICE PRACTICE

Layout of Drawing Boards and Drawing Equipment.

Reference material to be close to working space.

Reproduction of drawings, and the preparation of drawings for reproduction.

Storage of tracing paper negatives and drawings vertical and horizontal plan chests.

Typical reinforced concrete and steelwork drawings as prepared by the Structural Engineer to be available for discussion.

Keeping of Drawings lists, Job records, and methods of dealing with changes on drawings to ensure full circulation to all interested parties.

Time related to drawing production: essential drawings and selection of methods of producing in sequence.

Statutory form-filling and related drawings: essentials to meet Local Aurority requirements.

PORTFOLIO WORK

The purpose of the Portifolio is to be explained.

1. Portfolio Work for Submission at Part II

(i) A drawing sheet showing examples of the alphabet and numerals;

(ii) A drawing sheet in isometric;

(iii) A free-hand drawing;

(iv) An example of the development of a solid;

(v) An example of a working drawing on two sheets.

One to contain plan, Section and elevations: Scale 1:50

One to contain details: Scale 1:20, 1:5 and FULL SIZE

2. Portfolio Work for Submission at Part III

(i) The measured drawing of an existing building or part thereof, on at least two sheets, accompanied by the detailed notes. This could be carried out by not more than four students as a group-exercise.

(ii) A complete set of working drawings to be submitted from a sketch design provided. Guidance should be given as to the extent of work to be covered but at least four sheets of A2 size drawings should be done.

SURVEYING

Surveying should be dealt with from the needs of the Architect's office to be able to obtain all the necessary information for building design. From the initial survey, drawings of the survey should be prepared and their relationship to the geology etc. and the final building needs should be emphasised.

Subsequently the student should be able to set out vertical and horizontal datums on site, check grid lines and depths of basements.

The transfer of vertical dimensions in high rise buildings should be included.

The care and handling of simple instruments should be taught, and full-day practical exercises organised.

SURVEYING PART I

Detail Surveying

Introduction, description of tape, chain, optical square, arrows, etc. used in detail survey principles and methods. Definitions of base line, checks, tie lines and offsets.

Methods of booking treatment of obstacles, chaining and taping on sloping ground, conventional signs.

Levelling

Definition of important terms, description of Abney level, Dumpy level, tilting level and Cauley level.

Description of Automatic level, levelling staff.

Temporary and permanent adjustments for levels.

Principles of levelling, Bench Marks, Sea level datum, methods of booking and reducing levels, checks. Sources of error, precautions to reduce, errors, adjustment of closing error.

Cross sections, profiles, plotting of profile.

Contouring

Definition of contours and other terms; characteristics of contours, scale and contour interval.

Abstracting information from contours, profiles, determining intervisibility, interpolating contours from spot heights.

Methods of contouring, contour chasing, rectangular grid of spot heights, instruments which can be used, level, theodolite, tacheometer.

SURVEYING PART II

Setting out

Definition of terms, change, centre line BC, EC, etc., horizontal curves, setting out curves by offsets.

Setting out curves by deflection angles, curves defined by radius, degree of curve.

Problems in curve ranging, obstacles, use of line points.

Use of sight rails and boning rods, etc.

Setting out points in pre-computed position.

Setting out building geometrically.

Check by diagonals.

Plumbing devices and use for setting out vertically.

Plumbing shutters. Optical plummet - Cauley levels.

Earth Quantities

Mensuration, areas of figures with irregular boundaries,

Simpson's rule, average area, trapezoidal rule, prismoidal rule, prismoidal excess.

Volume of embankment with transverse slopes - examples.

Mass haul diagrams.

Introduction to plane table surveying.

Theodolite Surveying

Description and construction of modern theodolite, vernier and optical micrometer, terms used in theodolite surveying.

Setting up, centering and levelling, temporary adjustments, brief mention of permanent adjustments.

Measuring angles, horizontal and vertical, FL and FR repetition, booking and reduction of angles.

Introduction to co-ordinates and computing Whole Circle Bearing.
Description of traversing.

Methods of traversing, low order, high order, types of traverse, closed, unclosed loop, etc.

Computation of bearings from angles, office computation of traverse, adjustment of Bowditch method.

Computing a traverse from given data
Stadia measurements, principles of distances and heights by tacheometry, reduction by Redmonds tables.

Ⅱ－8　工学部　電気工学科　電気

CURRICULUM FOR JOMO KENYATTA COLLEGE OF AGRICULTURE AND TECHNOLOGY

ELECTRICAL ENGINEERING SECTION

1.1 The Electrical Engineering Section would offer two courses viz.

1. Electrical Installation Technician.

2. Electronic Engineering Technician.

1.2 The College would entrol the students for the courses in April/May each year and fifteen students would be accepted for each of the courses mentioned. There would be three teaching terms, each of 14 weeks, during each calender year.

1.3 To begin with, the duration of the course would be of three years and two terms. At the end of each course, the students would have reached the standard equivalent to Part 2 of the technician level. Later on, the attempts could be made so that the duration of the course would be four years and one term so that the additional two terms could be utilized to train the students upto Part 3 of technician level.

1.4 The students for the courses would have at least East African Certificate of Education with credit pass in English Language, Mathematics and a related Science Subject.

2.1 It is expected that the students would spend all the time at the College for the theoritical studies and the practical training relevant to the course.

2.2 Whenever necessary equipment and facilities are not available within the section for the practical training recommended, the students would be attached to outside firms, government departments and parastatal bodies during either College terms or vacations or both. To supplement the training provided by the section in the class-room, the laboratories and the Workshop of the College, the section may undertake contract jobs from Government and Private Sectors.

3.1 The details of the syllabuses to be followed for the academic studies and the practical training would be as per attached course documents.

3.2 The arrangement of the subjects to be studied during the course and the theoritical and the practical examinations to be taken would be as per attached sheet course Pattern.

3.3 For internal theoritical examinations, the College would set and mark them, such examinations would be for progressions and no certificate would be issued.

3.4 For the trade tests recommended, they could be external tests or internal tests organized with the help of external examiners. Proficiency Certificates should be issued for such tests.

3.5 For external examinations, those set by the East African Examinations Council would be utilized. The certificates would then be automatically issued by the E.A.E.C.

COURSE PATTERN

CALENDER YEAR	TERM	COURSE YEAR	SUBJECT STUDIED		EXAMINATIONS
			ELECTRICAL INSTALLATION	ELECTRONICS ENGINEERING	
	JAN.-APRIL	-	-	-	-
1	MAY-JULY	-	Mechanical Workshop. Craft Theory.	Mechanical Workshop. Craft Theory.	Trade test.
	SEPT.-DEC.	1	Electrical Principles. Related Studies.	Electrical Principles. Related Studies.	Internal Theoretical. Examination for progression.
	JAN.-APRIL		Electrical Workshop.		
2	MAY-JULY		Electrical Workshop. Electrical Principles.	Electrical Principles. Related Studies.	Trade Test. Internal Theoretical.
	SEPT.-DEC.	2			Examinations for progression.
	JAN.-APRIL		Installation Works & Regs. Associated Studies.	Electronic Components and Circuitry.	
3	MAY-JULY		Mathematics, Engineering Principles, Installation	Mathematics, Engineering Principles, Drawing and	
	SEPT.-DEC.	3	Technology, In-plant Practics	Processes, Radio and Electronics	Internal Technician Part I level for progression.
	JAN.-APRIL		Electrical Engineering Principles, Installation	Mathiematics, Electrical Principles, Radio and	External Technician Part 2 level.
4	MAY-JULY	4	Technology, Testing Methods and Reliability,	Electronics, Testing Methods, Industrial	
	SEPT.-DEC.		Consumer, Distribution System, In-plant Practice.	Electronics theory and Practice.	

ELECTRICAL INSTALLATION TECHNICIANS - FIRST YEAR

MECHANICAL WORKSHOP

Attention to be given to safe working methods.
Standard hand tools for bench fitter; description, care and maintenance including shears, scissors, side and fron cutters, spanner, description by type and size.
Simple marking out. Exercises using files, hacksaw, hammer and flat chisel, rule, squares and calipers.
Exercises in the manipulation of non-ferrous metal and insulating materials.

Exercises using centre-punches, hand-drills, taps and dies, screw-drivers and spanners. Standard threads in common use. Their application.
Use of measuring equipment, such as dividers, wire gauges, vernier caliper and micrometers.
Use of simple jigl and templates.
Introduction to portable power tools and drilling machines. Safety precautions. Use of coolants.
Latne work use of 3-jaw and 4-jaw chucks. Tool forms and cutting speeds for various materials.

CRAFT THEORY

Introduction in safety precautions when using tools. Codes of conduct in workshops. Variations in common tools and their applications.
Introduction to engineering materials such as iron, steel, copper, brass and aluminium.
Types and forms of screw thread screw and bolt heads correct sharpenning of turit drills. Tapping sizes. Introduction to precision measuring instruments, micrometers dial surfaces and depth gauges.
Introduction to tolerance limits and fits.
Mechanical and electrical properties of materials used as conductors and insulators.
Mechanical power transmission systems. Use and limitations of belt and chain driver, gears and clutches.
Safe method of lifting and handling. Use of pulley blocks, chain tackle, screw and hydraulic jacks, rollers and pucking.

ELECTRICAL PRINCIPLES

Structure of matter. Simple electron theory. An electric current considered as flow of electrons. Electric quantity.
The coulamb and the ampere.
Demonstration of heating, magnetic and chemical effects of electric current.
Illustration of applications conductors and insulators.
Electric circuit. Concept of resistance potential difference (involts) as the course of current flow. Ohm's law. Simple calculations.
Use of ammeter and voltmeter.
Series and parallel circuits with calculations.
Primary and secondary cells as sources of electrical energy.
Internal resistance. Cels in series and in parallel.
Resistivity and conductivity.
Beating elements. Effect of temperature on resistance.
Resistance of conductors and voltage drop in cables.
Rating of lamps, elements and resistors. Relationship between volts amperes and walls.
Electrical safety precautions. Earthing arrangements.
Rule of fire and shock. Aritificial respiration. Need for regulations.
Electro-magnetic devices, bells, buzzers, relays, contactors.
Simple bell and indicator circuits.
Over loads and short circuits. Causes, effects and protection by fuses.
Principles of protection and control by thermal and magnetic devices.
Types of supply e.c. single-phase a.c. and three phase a.c.
Potential differences between mains and earth. Control gear at consumers supply point.
Meaning of polarity in distribution circuits. Live and Neutral.
Correct connection of single-pole switches, fuses and neutral links.
Use of double pole switches. The magnetic field. Flux magnetizing forces.
Field due to a current through a straight wire, loop solenoid.
Magnetic materials, permanent magnets.
Force on a current carrying conductor in a magnetic field.
Basic principles of a moving coil instrument and d.c. motor.
Electro magnetic induction.
The transformer principle.
Moving coil & iron instruments.
Principles of telephone and loudspeaker. Simple telephone circuits.
Simple generator principle. Generation of alternating voltage, rectification by commutator.
Simple concept of alternating current, waveform, frequency. Root mean square, peak, mean and instantaneous values.
Introduction to basic a.c. circuit. Use of inductor and capacitor.

RELATED STUDIES

Arithmetic - general revision, including fractions, decimals and conversions, reciprocals, ratios and percentages. Calculations - areas of regular plane figures. Volumes and weights of simple solids.
Metric system of weights and measures.
Measurement and setting-out of angles, bisection of angles, construction of triangles and parallelograms. Interpretation of simple engineering drawings. Introduction to orthographic projection.
The dimensioning of engineering drawings and sketches.
Sketching of simple objects and machine parts, using pictorial views. Oblique and isometric.
Thermal expansion and contraction. Measurement of temperature centrigrade (kelvin) and Fahrenheit scales - conversion.
Sketching and dimensioning for cable acids and trunking.
Introduction to definitions from IEE Regs.
Drawing of wiring diagrams for lighting and power circuits.
Graphical symbols B. S. 3939.
Use of algebric notations. Use of formulae. Change of subject simple equations.
Direct and inverse proportion. Plotting and use of simple graphs.
Basic mechanics. Force units (including the newton) work and power.
Relations between mechanical and electrical units. Triangle and parallelogram of forces. Simple applications. Moment of force, torque.
Levers (with parallel forces), beam balances, weighing machines.
Mechanical and electrical units and the relationships between them.
Efficiency. Heat in the form of energy. Units of heat. Specific heat.
Relationship between electrical and heat units.

ELECTRICAL WORKSHOP

Artificial respiration. Electric shock. Need for safety and core.
Care and use of hand tools.
Types of cables used and methods of termination with exercises.
Connection of wiring to fuse terminals switches cekling roses etc.
Fixed sheathed wiring.
Flexible cords, wiring of ceiling roses and lamp holders. Attention to details.
Use of wire gauges and micrometers to classify cables/conductors.
Consumers control units construction and wiring arrangements.
Termination to socket-outlets and plugs. Correct colour code. Wiring simple circuits including switches lamps and pocket-outlets. Bell circuits with indicators. Experiments with cells in series and parallel.
Sheet metal working, marking out, cutting drilling punching, bending riviting etc.

ELECTRICAL INSTALLATION TECHNICIANS - SECOND YEAR

ELECTRICAL WORKSHOP

Need for safety.
Care and use of blow lamps, gas torches, and soldering irons.
Sweating of lugs or cables, use of fluxes. Crimping tools.
Care and use of portable equipment maintenance and faultfinding.
Conduit threading, taps and reamers. Care and use of stocks and dier.
Methods of fixing conduit surface and sunk work.
Erection of simple trunking systems.
Exercises in conduit using all typs of terminating boxes.
Use of testing instruments.
Mineral-insulated cable, termination tools required setting, fixing.
(Copper and aluminum conductors.)
Bell circuits with relays.
Wiring discharge lighting internal circuits.
Terminating armored cables (small twin cables only).
Wiring up of different starters to motors and fault location.
Fault location on completed work, including polarity, earthing, insulation and ring circuit continuity.
Use of multirange instruments for checking motors.
Tests on E. LCBds.
Fire alarm and cell circuits.
Mounting and lining up of machines.

ELECTRICAL PRINCIPLES

Electromagnetic induction, self and mutual inductance.
Induced e.m.f. by change of flux linkage.
Energy stored in an energized coil, switching of inductive circuits.
Unit of inductance.
Properties of common magnetic materials. Principle of magnetic shielding.
Energy losses due to reversals of excitation and to rotation in a magnetic field. Hysteresis. Eddy currents. Laminated magnetic systems.
Principle of the alternating and the unidirectional generator.
Relationship between speed, pole pairs and frequency. The relationship between speed, field strength and generated e.m.f.
The operation of the d.c. machine as a motor or as a generator.
The voltage equation ($V = E + IR$). Forms of excitation.
The production of torque. Load characteristics.
The polyphase a.c. generator. General concept of a Polyphase system.
Star and Delta connections. The three phase 4 wire and 3 wire systems.
Production of rotating field by a polyphase winding system.

Production of torque in synchronous and osynchronous machines.
Starting arrangements. Capacitors, the electric field, electric stress, dielectrics. Series and parallel combinations. The parallel plate capacitor. Unit of capacitance p.d. and charges, stored energy.
Working voltages. Safety precautions when using capacitors.
Variable and semi-variable air-spaced and solid dielectric types.
The electrolyte capacitor principle. Resistance and inductance in a d.c. circuit, simple concept of LR Time constant.
Inductance in an a.c. circuit. Phase angle and inductive reactance, inductance and resistance in series, impedance and phase angle.
Capacitance and resistance in a d.c. circuit. Simple concept of CR Time constant. Capacitance in a.c. circuit, phase angle and capacitive reactances, capacitance and resistance in series, impedance and phase angle.
Inductances, capacitance and resistance in series, resonance.
Two branch parallel circuit consisting of (a) inductance - resistance and (b) capacitance. Effects of resonance.
Power in a.c. single-phase circuits. Power factor. Active and reactive components - KW & RVAR.
Power factor correction by static method.
Principle of cathode ray tube. Simple application as an oscilloscope.

ELECTRICAL PRINCIPLES (CONT)

Rectifiers. Metal rectifiers. Semi-conductor diode, meaning of Forward Resistance and Reverse Breakdown Voltage. Voltage and temperature limitations. Rectification. Half-wave and fullwave Average value, use of receiver capacitor, surge current, ripple voltage, smoothing Transformers, core construction of shell, ring and core types. Transformation ratio. Relationship between primary and secondary ampere-turns. Regulation and corses (descriptive treatment). Use of tappings. The auto-transformer. Voltage and current transformer.
Instruments, moving coil and rectifier moving coil, moving iron, thermo-couple and dynamometer instruments. Extension of range-series resistors shunts.
Sensitivity ohm/volt. meter errors in high-resistnace circuit and in low-voltage, low-resistnace circuit. The uses of the valves voltmeter.
Principle of the wheatstone Bridge network (balanced) variable in standard and variable ratio types.

INSTALLATION WORK AND REGS

Use of mineral - insulated cables and cable glands, IEE Regulations on the use of these systems. Wiring of bell-circuits with indicators (simple). Transformer operated bell system. Relevant IEE Regs.
Simple testing of basic circuits. Use of insulation and continuity tester.
Sketching of simple objects e.g. fixing brackets, sheet metal trunking, terminals and fuses.
Graphical symbols to Bs 3939.
The effect of the Electricity (Factory Act) Special Regulations on Electrical Installation Work.
Detailed study of the following parts of IEE Wiring Regs.

(a) Whole of Part I
(b) Sections ABCDEFG&H of Part II
(c) Tables section
(d) Appendices 1-8

Transmission and distribution systems over head and under ground.
Advantages of the a.c. system, standard pressures for transmission and distribution.
General discription only of: Electricity supply systems, grid and super grid and associated power stations, substations, bulk supply and distribution, control centres.
Three phase, three-wire and four-wire a.c. distribution systems.
Distribution centres. Power load, assessment of diversity and grow factors. Switch boards, isolation. Control labelling, provision o space-ways. Systems of distribution with a consumers installation.
Rising mains and ring main system. Phasing and balancing of single phase loads on a polyphase system. Application of different types of switch gear, oil and air-break contacts, are extinction methods.
Distribution boards for power and lighting circuits, fuse elements and their uses. Metering. Arrangement of an installation to provide for discriminative operation of excess current protection various types of rigid and flexible conduits including light and heavy gauge steel, aluminium and non-metallic types. Cable trunking systems including underfloor and vertical ducts, overhead bus-bar systems. Installation of conduit systems surface, concealed, loop-in. Installation of p.v.c. and paper-insulated armored cables and mineral insulated cables including methods and problems associated with termination (copper and aluminium conductors).
General appreciation of installations requireing special consideration e.g. out door installations, systems subject to extremes of temperature, flammable or explosive situations, garages.
Earth concentric wiring.
Earthing systems, earth-top impedance, construction, application and installation of C.O. & V.O. EL.CB's methods of testing.

Testing of an installation, polarity, earthing, insulation and continuity of a ring circuit.
Fault detection and location.
Interpretation and use of layout drawings for installations including schematic diagrams. Preparation "as fitted" drawings.
Installation and use of voltage and current transformers.
Application to protective and measuring circuits.
Layout of installation to provide for on-peak and off-peak supplies (ripple control).
Installation and maintenance of secondary cells, use of hydrometer
Charging devices and circuits charge and discharge characteristics of lead-acid and alkaline cells. Secondary and emergency lighting systems.
Courses and prevention of corrosion, with particular reference to electrolytic action.
Fire systems on open and closed circuit principle with zone classification and indication. (General installation practice only.)
Call systems and burglar systems (general installation practice only).
Behavior and users of different types of motors and generators, d.c. series, shunt and compound types a.c. three-phase cage and wound rotor induction motors, single phase cage induction motors, split phase, capacitor start, a.c. series. Types of enclosure. Rating starting methods and circuit diagrams. Means of reversal of rotation. Relevant IEE Regulations.
Installation, including mounting and lining up of machines.
RVA rating of a.c. plant; power factor, installation of equipment to improve power factor.
Maintenance and testing for faults in switchgear, starters and motors, common faults. Construction site installations and safety requirements.
Lighting. Factors affecting interior illumination levels. Types of lamps and fluorescent tubes, including their ratings of light-out put and efficiency. Installation of electric signs, discharge lamps and fluorescent tubes, starting and control gear circuits simple types of domestic water heaters, their installation and control.
Preparation of requisitions for wiring materials required forasimple installation.

ASSOCIATED STUDIES

Level systems, compound levers and linkages. Toggle. Simple mechanisms, the eccentric cam, crank, pawl and ratchet. General principle of operation of springs applied to electrical apparatus.
Work, energy and power units of the mechanical and thermal system and their electrical equivalents. Inter-relation of units.

Simple consideration of the conservation of energy and the occurrance of losses, meaning of efficiency of energy transfers.
Machines, rope and chain lifting gear, winch, work and worm wheel, screw jack, the wedge, gear trains. Efficiency. The principle of work.
Torque, work done byatorque. Velocity and acceleration (simple treatment
Graphs, plotting, meaning and uses, graphs of current/voltage resistance/length, resistance/temperature, in/cm, load/extension, meaning of $y = m + c$ and graphical determination of constants e.g. Effort = $aW + b$, $E = a(+b$, $R = at + b$.

THIRD YEAR

Part I of E.I.I. course.

FOURTH YEAR

Part II of E.I.I. course.

280 - ELECTRICAL INSTALLATION TECHNICIANS THIRD YEAR

NOTE: SAFETY

It is essential that particular emphasis be placed at all times on safety and safety precautions in the laboratory and workshop. The attention of students should be drawn to the provisions of the Electricity Supply Regulations, The Factories Acts, The Offices, Shops and Railway Premises Act, and the I.E.E. Regulations for the Electrical Equipment of Buildings, and they must be warned of the hazards involved in handling electrical equipment.
Instruction should be given in the safety precautions to be observed before making connections to 'live' mains, or switching on equipment which may be so connected. Students should be made aware of the location and method of operation of isolating switches and other safety devices, and should receive instruction in simple first aid and artificial respiration in cases of electric shock. Posters should be prominently displayed.
It is not intended that this be treated in a series of formal lectures, but the importance of safety precautions for both personnel and equipment should be continually brought to the notice of all students using the laboratories and workshops.

PART I

ENGINEERING PRINCIPLES*

FIRST YEAR (T.1)(80 hours)

Through this syllabus the S. I. system of units should be used, but there should be frequent reference to the relationships with, and conversion to, other systems in use.

1. FORCE

Revision of definitions and units of mass, force and weight; scalar and vector representation of a force, friction and friction force as times normal reaction. Resultant of two forces acting at a point determined graphically and by taking rectangular components; resolution of a single force into rectangular components, application to simple practical problems. Triangle of forces and extension to polygon of forces; resolution of forces graphically and by resolution into components. Description of the turning effect of a force, unit of torque, calculation of torque for simple practical problems.

* This syllabus is identical with the T.1 Engineering Science syllabus in Telecommunication Technicians.

2. WORK, ENERGY AND POWER

Unit of work, work done by a force applied (a) along and (b) at an angle to, the line of motion, work done in lifting and against friction, work done by a torque. Power as a rate of doing work, energy; simple treatment of energy of a body by reason of its position and of its motion, loss and gain of energy. Losses: output as input minus losses. Efficiency: definition as output/input, percentage and per-unit presentation, accuracy of calculation when input and output are approximately equal.

3. STRESS AND STRAIN

Types of simple stress (tensile, compressive and shear). Relationship between stress and strain within the elastic limit; typical load/extension graphs for ductile and brittle materials and their simple physical limitations; simple statement of Young's modulus and meaning of safety factor. Simple springs.

4. LINEAR MOTION

Definition of velocity and acceleration, units. Distance-time and velocity-time graphs. Resolution of velocities. Introduction to Newton's Laws of Motion and the relation between force, mass and acceleration, simple problems on practical fraction, problems involving lifts, hoists and vehicles. Meaning of inertia of a body.

5. ANGULAR MOTION

Definition of angular velocity and acceleration, units, the relationship between linear and angular velocity. Factors affecting the inertia of a body, descriptive treatment of energy stored; purpose of the flywheel.

6. MACHINES

The function of machines. Definitions of velocity ratio and mechanical advantage and their calculation for simple machines, such as lever, screw-jack and gear train.

7. HEAT

Descriptive treatment of expansion of liquids and solids, definition of coefficient of linear expansion, applications, e.g. thermometer, bimetal relay, expnasion in civil engineering structure, simple thermostats. Simple treatment of transfer of heat by conduction, convection and radiation, proctical application such as heat sinks and cooling of equipment.

8. DIRECT CURRENT CIRCUITS

Elementary idea of current flow; description without units of current, including difference between alternating and direct current; quantity of electricity as number of static or motional charges; impedance as resistance or opposition to current flow; difference between conductors, semi-conductors, resistors (including idea of non-linear resistor) and insulators; electronotive force as 'driving voltage' produced by a sources; potential difference as voltage required to force current through resistance; capacitance as charge per unit potential difference. Energy as heat; energy produced by current flow through resistnace; simple ides of potential energy of stored charge. Power as rate of doing work; units of current, quantity, voltage (energy/unit-charge) and resistance; Ohm's Law. Electro-chemical effects; chemical effect of a current. Faraday's Law of electrolysis and application; corrosion. Primary cells, Secondary cells; lead-acid and alkaline cells (non-chemical descriptions), characteristics, internal resistance. Series and parallel connection of cells. Principles of charging methods. Basic maintenance. Resistors in series and parallel, relationship between resistance and conductor dimensions and dependence on material, resistivity (dimensions e.g. ohm-metre as resistance-length); conductivity as reciprocal of resistivity and d.c. conductance as reciprocal of d.c. resistance. Effect of temperature on resistance (intorduced graphically), temperatur coefficient of resistance referred to any base temperature.

9. MAGNETISM AND ELECTROMAGNETISM

Permanent magnets, field distribution for common attangements. Magnetic effect of a current; description of field produced by a straight conductor, two parallel conductors and a coil. Concepts of a magnetic field, flux and flux density. Force on a current carrying conductor in a field as B.7.1. and hance definition of units of flux density and flux; practical application of this force such as motor and moving-coil meter and blow-out coil. Idea of force between parallel conductor and turns of a coil with practical applications; but no calculations (other than by use of definition of unit current). Induced e.m.f. in moving and stationary circuits; practical applications such as generator principle (with field conductor moved);

Faraday's Law of electomagnetic induction, Lenz's Law. Mutual and self induction. Generation of an alternating e.m.f. by the rotation of a coil in a uniform magnetic field.
Flow of alternating current in a pure resistor.

10. INSTRUMENTS

The use of ammeters and voltmeters. The effect of instrument resistance on circuit conditions. Shunts and multipliers.

SECOND YEAR (T.2)*(80 hours)

11. CIRCUIT THEORY

More advanced direct current circuit problems on the parallel circuit, the series-parallel circuit, Kirchhoff's Law and Superposition principle applied to simple series-parallel circuits.
Electrical power and energy units and relationship with mechanical and thermal units. Calculations on power and energy dissipated in simple series and parallel circuit. Heating effect of a current, Joule's equivalent in terms of electrical quantities.
Examples of methods of transfer of power and energy in different forms including simple calculations and efficiency of conversion.
Simple problems on cost of energy.

12. ELECTROMAGNETISM

The magnetic circuit; magneto-motive force, magnetizing force, permeability and reluctance (a parallel should be drawn between these and equivalent quantities in the electric circuit), the dependance of relative permeability on field strength and flux density, description of magnetization curve and hystresis loop, idea that energy loss is associated with the loop but no calculations. Magnetic circuit calculations for series circuits using magnetization curve or ampere-turn method of solution excluding leakage and fringing.
Induced e.m.f. direction, magnitude determined from rated of change of flux linkage. Description of effects of self and mutual inductance, direction of induced e.m.f. calculation of e.m.f. of self and mutual inductance from rate of change of flux linkage or rate of change of current; unit of self and mutual inductance. Statement of energy stored an inductor as $1/2\ LI^2$ joules. Practical applications such as ignition system, transformer, etc.

13. ELECTRIC FIELD

Flux and flux density (a parallel to be drawn with magnetic and electric circuit).
Demonstration of storage of charge; relationship between charge and applied voltage and hence definition of unit of capacitance.
Statement of energy stored in a charged capacitor as $1/2\ CV^2$ joules.
Examples of construction of fixed and variable capacitors.
Capacitors in series and parallel and hence relationship between capacitance and dimensions. Permitivity.
Capacitance of the parallel plate capacitor. Introduction to potential gradient and dielectric breadown.

14. ALTERNATING CURRENTS

Generation of e.m.f. in a single coil. Definition of cycle, period and frequency. Reason for use of sine wave; half-wave average, peak and r.m.s. values by graphical means, form and peak factors. Meaning of phase and magnitude (amplitude). Waveform plotting from rotating vector, addition and subtraction of sine waves, resultant wave, effect of phase shift, use of phasors (vectors) for addition and subtraction; comparison of resultant with that obtained by plotting waves. Effect of resistance, inductance and capacitance considered saparately. Behaviour of pure inductance and pure capacitance only in series. Power in a.c. circuits, unity and zero power factor only.

15. MEASUREMENTS AND INSTRUMENTS

Essential features of an indicating instrument, i.e. devices for defecting, controlling and damping. List of instruments in general use and their applications. Simple descriptive treatment of operation of moving coil and moving iron instruments. Calculation of value of shunts and multipliers. Measurement of resistance by ammeter-voltmeter method (including allowance for effect of introduction of instruments) and by substitution. Principle and application of the Wheatstone bridge. Principle of the simple d.c. potentiometer, standardizing, application to measurement of potential difference, current and resistnace.

16. ELECTRONICS

Elementary qualitative treatment of the theory of semi-conductors. The p-n junction. Thermionic emission. The simple diode; space charge saturation; recrifying action. Types of rectifier, their characteristics and principles of operation. Single-phase, half-wave, full-wave and bridge connections. Smoothing circuits. Comparison of input and output waveforms.

17. MACHINES

Essential features of a d.c. machine. Methods of connection of field circuits. Descriptive treatment of operation of motor and generator. Need for starter and description of d.c. face-plate starter. Essential features of an alternator, (e.g. need for d.c. field system, armature, slip-rings etc.), simple descriptive comparison of rotating and stationary fields and of salient pole and cylindrical rotors, synchronous speed.

18. CIRCUITS

Series or parallel combinations of resistance, inductance and capacitance, with constant supply conditions. [Treatment can be graphical or by calculation (resolving) but should be simple and the parallel case should be restricted to two branches. There should be copious use of phasor (vector) diagrams and it is not intended that symbolic notation should be used.] Power and power-factor; meaning of active and reactive components of current, meaning of volt-ampere, volt-ampere reactive and watt.

* Except for the EITHER/OR paragraphs at the end, this syllabus is identical with T.2 Telecommunication Principles A in Telecommunication Technicians.

MATHEMATICS*

1. ARITHMETIC

Conversion of weights and measures from British to metric systems; practice in making approximate conversions. Use of simple conversion graphs for this purpose. Introduction to and the use of algebraic symbols in addition, subtraction, multiplication and division processes and in the addition and subtraction of simple fractions.

2. DIRECT PROPORTION

With special reference to

(a) volumes of solieds and their weights,
(b) variation in extension and compression of a spring by application of different forces,
(c) circumferences of circles and their radii. Calculation of circumferential speeds of rotating wheels and of simple gear ratios,
(d) percentage and per-unit values.

3. AIDS TO CALCULATIONS

Appliximate calculations, their use generally and in particular when using a slide rule. The meaning of a logarithm and the use of logarithmic tables for multiplication and division. Use of tables for squares, square roots and reciprocals. Appreciation of error; simple practical example, e.g., limitations of instruments; need for use of significant figures.
Standard form and its use in dealing with unwieldy numbers, e.g.,

$2240 = 2.24 \times 10^{3}; 0.00427 = 4.27 \times 10^{-3}$

Construction of the slide-rule. Comparison of results obtained by slide-rule with those obtained by logarithms, during the solution of examples involving multiplication and division processes. Further use of the slide-rule for obtaining squares and square roots; comparison with result obtained from tables.

4. ALGEBRA

Simple algebraic processes. Emphasis on the use of symbols in common use. The insertion and removal of various forms of brackets, e.g.,

$3 \times [a-2a(1-p)]$.

Simple factors and their uses in simplifying algebraic fractions, e.g.,

$a^2-b^2 = (a+b)(a-b); x+1 = x(1+\frac{1}{x})$

Addition, subtraction and multiplication of algebraic fractions, e.g.,

$$\frac{1}{x} - \frac{3}{5x} + 2; \frac{p^2q-pq^2}{3pq}; \frac{3}{2m} \times \frac{5m^2}{4}$$

Indices and their laws. Positive and negative whole number powers. Powers of ten; common logarithms.

5. GRAPHS

Plotting of graphs from equations of the forms $y = mx + c$ and $y = \frac{1}{x}$

Plotting of graphs from experimental results; obtaining information from graphs. Determination of the law from a straight line graph; meaning of the slope and the intercept.
The advantages and limitations of graphical presentation.

6. FORMULAE

Formation and solution of simple linear equations. Transposition of simple formulae, e.g.,

$R = \frac{pl}{a}$; $v = u + ft$; $R_1 + R_0(1 + at_1)$.

Evaluation of formulae using practical values. Linear simultaneous equations in 2 unknowns.

7. MENSURATION

Mensuration of rectangle, triangle, circle, cone, cylinder and sphere. Practical examples in engineering.

8. GEOMETRY

Properties of parallel lines. Types of triangles, sum of the angles of a triangle; similar triangle.
The Theorem of Pythagoras and its applications.

9. TRIGONOMETRY

Trigonometrical ratios from 0° to 90° (sine, cosine and tangent); particular reference to triangles having angles of 30°, 60° and 90° and of 45° and 90°. Use of trigonometrical tables. Solution of right-angled triangles; verification by scale drawings. Graphical representation of $y = \sin \theta$ and $y = a \cos \theta$ for angles 0° to 360° by projection from a rotating phasor.

SECOND YEAR (T.2)*(60 hours)

10. TRIGONOMETRY

Sine, cosine and tangent of angles of any magnitude; graphical appreciation of these ratios. Circular measures: the radian.

The relationship $\frac{\sin \theta}{\cos \theta} = \tan \theta$, $\sin^2\theta + \cos^2\theta = 1$.

Simple problems involving these relationships. Definition of cosecant and cotangent. Further work involving the graphs of $y = A \sin \theta$ and $y = A \cos \theta$. Plotting and sketching of sinusoidal functions with variation of magnitude and phase; relationship between angular and time scales. Graphical addition of sine waves of differing magnitude and phase.

11. VECTOR

Resultants obtained by Pythagoras' Theorem, by simple trigonometry and by resolution of vectors. Application of phasors (vectors) in the solution of electrical problems.

12. ALGEBRA

Further work on indices, fractional powers with positive and negative values. Manipulation of algebraic expressions, such as

$$I = \frac{V}{\sqrt{R^2 + (\omega L - \frac{1}{\omega c})^2}}$$

$S = ut + 1/2ft^2; I = ad^n;$

$\sqrt[3]{a^2b^4} \div \frac{\sqrt{a}}{b}; ax^2 + az + cx^2 + cz;$

$$\frac{1}{m+n} - \frac{1}{m-n} + \frac{1}{m^2+2mn+n^2}$$

The formation and solution of simultaneous equations involving two unknowns. Simple electrical circuit problems. The formation of quadratic equations and their solution by factors and by the use of formulae (without proof). Practical problems involving quadratic equations, e.g., $P = VI + I^2R$.

13. GRAPHS

Graphical solution of simultaneous and quadratic equations. Determination of laws of the term $y = ax^n$; the effect on the shape of the graph of varying a and n. Solution by conversion to straight line form by the use of logarithmic paper.

14. GEOMETRY

The solution of triangles by sine and cosine rules; the area of any triangle. Problems on heights and distances. Chord, angle and tangent properties of the circle, without proof.
Principle of the centering gauge; marking out exercises involving the lengths and heights of arcs. The mid-ordinare rule; the determination of the areas of irregular figures; average value and r.m.s. value of alternating current waveforms. The areas and volumes of spheres, cylinders and cones.

15. AIDS TO CALCULATION

Use of the slide-rule and tables for more advanced problems; checking by appropriate calculations. The use of logarithms to bases other than ten, e.g., two; the binary notation of numbers.
Use of calculating machines.

* This syllabus is identical with the T.2 Mathematics A syllabus in Telecommunication Technicians.

INSTALLATION TECHNOLOGY I AND II (240 HOURS)

FIRST AND SECOND YEARS (T.1 and T.2)

NOTE: The content of the syllabuses in Installation Technology is intended to be such that students become thoroughly familiar with the current 'Regulations for Electrical Equipment of Buildings' issued by the Institution of Electrical Engineers, and acquire the knowledge needed for the satisfactory understanding and interpretation of them. Because the syllabus is intended for Installation Technicians and not Craftmen students should do sufficient practical work to enable them to understand the problems involved in designing Electrical Institutions to suit different environments and to supervise the Craftmen required to carry out the installation. The physical properties of various materials used for conduits, fittings, accessories, cables and flexible cords should be studied concurrently with their use in electrical installation. The importance of the variation of the physical properties of the material with variation in environment should be stressed, e.g., temperature, humidity, fumes.

1. Introduction to the basic function and requirements of an electrical installation. Simple description of the electrical supply system; Grid and Super-Grid and assiciated power stations; control centre; sub-stations; bulk supply and distribution. D.C. and a.c. systems, single and three-phase systems; the advantage of the a.c. three-phase system; 3-wire and 4-wire distribution systems.

2. The necessary for regulations and safety of life and property. Introductory paragraphs, definitions and Part I of the I.E.E. Regulations. The effect of the Electricity (Factory Act) Special Regulations - 1908 and 1944 on Electrical Installation Work. Recommended supply voltage for domestic installations and for hazardous situations (for portable and garden tools). Procedure in the case of electric shock, artificial respiration.

3. Detailed study of Part II, the tables and appendices of the I.E.E. Regulations for the Electrical Equipment of Buildings with respect to the following types of installation: domestic, offices, schools, and inductrial.

4. Systems of distribution within the consumers installation. Rising and ring mains. Balancing of single-phase loads on 3-phase systems. Distribution boards for power and lighting circuits.
Earthed concentric wiring. Protection; fuses, miniature and moulded circuit breakers, excess-current protection, coarse and close protection.

5. General layout of lighting and power circuits including radial and ring circuits and busbar arrangements. Description and use of p.v.c., mineral and rubber insulated cables, plain and sheathed cables, flexible cords and cables. Various types of rigid and flexible conduits including light and heavy gauge steel, aluminium and non-metallic types. The need for and use of trunking, risers and ducting. Fitting, accessories, conduit and trunking. Bell and Cell circuits including indicators; associated transformer-operated systems.

6. General appreciation of installations requiring special consideration, e.g., outdoor installations, systems subject to extremes of temperature and other industrial hazards.

7. The physical properties of metals and insulating materials used in electrical installations and associated equipment. Application to cables, conduit etc. Causes and prevention of corrosion.
Effect of temperature and humidity.

8. Metal jointing by soldering, crimping and brazing, solders and spelter; precautions to be taken with electrical connections.
Jointing of metals and insulating materials; welding; nuts, bolts and rivets; adhesives. Wall and floor fixing screws, bolts, saddles etc. Cable joints and terminations.

9. Description, use and jointing of mains and distribution cables, including paper-insulated, for medium voltages.

10. Installation and maintenance of secondary cells; lead-acid, alkaline and zinc-air cells; charging devices and circuits. Secondary and emergency lighting systems. Earthing systems; earth-loop impedance, current and voltage-operated earth-leakage circuit-breakers, method of testing.

11. Insulation, continuity and polarity tests on an installation.
Use of insulation and conductivity meters, simple fault diagnosis.

12. Behaviour and uses of different types of a.c. motors and generators. Simple theory of a.c. and induction motors. Starting methods and circuit diagrams. KVA rating of a.c. plant, power factor; use of capacitors to improve power factor. Types of domestic water and space heaters, installation and control.

13. Preparation of requisitions for wiring materials required for an installation. Correct nomenclature.

14. Lighting. The meaning of the candels, the lumen and the lux. Simple calculations involving the invers square law and cosine law. Types of incandescent and discharge lamps, including the ratings of light output and efficiency. Circuitry and principles of operation.

SKETCHING AND DRAWING

NOTE: Particular attention should be paid to sketching. At the end of the course students should be able to make intelligible dimensioned free-hand sketches on square paper and to read drawings normally encountered in electrical installation work. Drawings should be dimensioned in British or metric units.

Introduction to orthographic projection and scale drawing. Freehand sketching including dimensioning of components such as switches, fuses, distribution boards, brackets, screw threads, and types of screws and bolts, including dimensioning and lettering. Drawing and sketching of distribution panels, frameworks and equipment layout. Interpretation of simple engineering drawing and architect's plans and layouts. Preparation of 'as fitted' and record drawings. Drawing of wiring and circuit diagrams. The use of B.S. graphical symbols (appendix 8 of the I.E.E. Regulations for the Electrical Equipment of Buildings). Block, schematic and sequence diagrams. Freehand sketching of single and multiple sine waves of different phase and frequency.

TECHNICAL REPORTS

NOTE: It is important that a technician should be capable of communicating efficiently with technologists and with craftmen, and in order to develop such skill he must undertake a serious study of various methods of communication. The following broad syllabus been prepared for technical reports. This syllabus should be spread over two years.

1. The understanding of the I.E.E. Regulations for Electrical Equipment of Buildings is important to Electrical Installation Technicians and they should be used freely in exercises chosen to illustrate the syllabus content.

2. Different methods of communication, the use of the spoken word, participation in lectures, debates and discussions. The written word, note taking and the expansion of notes to forma report; letter-writing. Summarizing and indexing, preparation of precis. Use of tables, graphs and charts in reports. Comprehension and interpretation of the I.E.E. Regulations for the Electrical Equipment of Buildings; Codes of Practice; Factory Acts, etc.

3. Each student to prepare a 1,500-2,000 word report involving the use of library, catalogues, etc.

PART II

ELECTRICAL ENGINEERING PRINCIPLES III*

THIRD YEAR (T.3)

1. D.C. MACHINES

Introduction to d.c. machines as an energy converter by reference to previous work on production of e.m.f. by movement of conductor in a magnetic field ($e = B.l.v.$) and force on a current carrying conductor in a magnetic field ($F = B.I.l$). The need for a commutating device to ensure uni-directional output or a reversal of current direction; only very simple constructional details to be considered.
Mode of operation of the machine, depending upon the direction of the armature current and its relation to the direction of electro-mechanical energy conversion. $V = E \quad I_a R_a$ related to the direction of armature current. Equation for generated e.m.f., the effects of lap or wave armature winding on the magnotude of e.m.f. and armature current. (Developed armature winding diagrams are not required.)
Equation for motor torque. Field circuit connections and associated machine characteristics (developed from Eanǫ and Taǫla): shunt and compound generators, self-excitation and causes of failure to excite; shunt, series and compound motors. Control of generated e.m.f. by field resistnace. Simple control of speed by field and armature circuit resistnace variation and by armature voltage variation.

2. NETWORK THEOREMS

Concepts of constant voltage and constant current sources.
The theorems of Maxwell, Thévènin and Norton and their use in resolving resistive networks into their simplest equivalent form. Maximum power transfer theorem (resistive components only); matching of load to source using transformers. Concept to input and output resistance.

3. ALTERNATING CURRENT CIRCUITS

Series and parallel circuits; power and power-factor. Simple treatment of effects of frequency variation on inductive and capacitive reactance, and hence the change of impedance, power and power-factor of a series R, L, C, circuit.

Impure components, loss angle and relationship between loss angle and power-factor. Series resonance with constant grequency variable reactance and constant inductance/capacitance with variable frequency; current/frequency curve, effect of variation of resistance; voltages developed across components; Q-factor.
Resonance of a parallel circuit with L and R in one branch and C only in the other. (Note: Phasor diagrams supported by trigonometrical and graphical methods should be used for the solution of problems, particular attention being given to the in-phase and quadrature components of the current.) Power-factor improvement using static capacitors.

4. D.C. TRANSIENTS

Growth and decay of voltage in resistance-capacitance circuits; time constant. Growth and decay of current in resistance-inductance circuits; time constant. Students will not be expected to reproduce proofs of derivation of formulae.

* This sullabus is identical with the T.3 Mathematics syllabus of the Electrical Technicians' Course.

5. THREE-PHASE SUPPLY

Nature of a 3-phase supply and its use in generation, transmission and distribution. Star and delta connection of a voltage source and of a balanced load; phase and magnitude relationships for line and phase current and voltage. 3-phase, 3-wire and 3-phase, 4-wire systems. Calculation of power in balanced 3-phase systems.

6. TRANSFORMERS

Single-phase transformer; essential features of construction.
Operation on no-load, considering primary winding only and treating it as a reactor; phasor diagram for this condition.
Expressions for induced e.m.f.'s in primary and secondary windings respectively; voltage per turn; voltage, current and turns ratios.
Nature and effect of iron losses and methods of minimizing these losses; efficiency. Effects of secondary loading on primary current and power-factor; simple phasor diagram.

7. INSTRUMENTS AND MEASUREMENTS

The electro-dynamic instrument; basic construction and operation as a wattmeter. Alternative wattmeter connections in a single-phase in a single-phase circuit and corrections to be applied. Instrument grades and expected errors. Choice of instrument. Use of instrument transformers to extend the range; methods of connection. Appreciation and use of multi-range and multi-purpose instruments. Simple treatment of principles of operation of cathode-ray tube and use for visual demonstration of voltage and current. Resistance measurement; revision of principle of Wheatstone bridge, use of a commercial d.c. potentiometer and its applications. Construction and operation of ohm-meter; insulation resistance and continuity tester.

8. TYPES OF AMPLIFIER

Function, application and specification of voltage and power amplifiers of the following types: low frequency, wide-band, d.c., tuned, thermionic, solid-state, magnetic and rotating (precise details are not required).

MATHEMATICS III*

1. ALGEBRA

Further work on factors, indices simplification of fractions and transportation of formulae. The formulation and solution of simultaneous equations involving more than two unknowns, e.g. electrical circuit networks containing several branches or meshes. Logarithmic equations; their formation and use. Natural logarithms. The relationship between natural logarithms and common logarithms. The graphical representation of e^{x} and e^{-x}. Application to practical Problems.

2. TRIGONOMETRY

Further work on ratios of angles of any magnitude; checking by reference to sketches of the functions; applications to electrical problems. Graphical and mathematical represnetation of a cosine wave as a displaced sine wave. Summaring of e.m.f.'s acting in an electrical circuit by the use of the identity $a \sin \theta \pm b \cos \theta = r \sin \theta \pm a$; checking by use of reasonably accurate sketches.

Vector and graphical addition of sine waves of differing magnitude and phase. The identities of $\sec^2\theta = 1 + \tan^2\theta$ and $\text{cosec}^2 A = 1 + \cot^2 A$ and their applications. The expansion of sin (A ± B), cos (A ± B), tan(A ± B). The double angle formulae,

$\sin^2\theta = 1/2(1 - \cos 2\theta)$ and $\cos^2\theta = 1/2(1 + \cos 2\theta)$.
Simple trigonometrical equations and multiple solutions where appropriate.

* This syllabus is identical with the T.3 Mathematics Syllabus of the Electrical Technicians' Course.

3. GRAPHS

The plotting and sketching of more difficult trigonometrical functions, e.g. $y = \tan\theta$, $y = a \sin n\theta$, $y = a \cos n\theta$.

$y = a \cos(2\theta \pm a)$f = I sin $(\frac{\theta}{2} \pm a)$.

Plotting of growth and decay curves.

4. DIFFERENTIATION

Graphical consideration of rates of change. Slope at a point on a curve. Practical applications such as velocity, acceleration and induced e.m.f.'s as rates of change. Differentiation by first principles of simple expressions, e.g. $y = 2x + 3$, $z = 3q^2$.
Differantiation of ax^n by rule.
Differential coefficients of sin θ, cos θ, e^{kx} and lnx.
Differentiation of expressions involving products and quotients.
Introduction to problems involving maximum and minimum values with discrimination graphically or by consideration of 2nd differential coefficient. Practical examples.

5. INTEGRATION

The reverse process of differentiation and its application to functions of the form

$ax + b$, ax^n, $\frac{1}{x}$, e^{kx}, sin θ, cos θ, $\sin^2\theta$, $\cos^2\theta$.

The significance of the constant of integration in practical problems involving, for example, velocity and acceleration. The definite integral. The use of integration for determining the area under a curve and the r.m.s. value of a sine wave. Comparison with results obtained by use of the mid-ordinate rule.

INSTALLATION TECHNOLOGY III AND IV

THIRD AND FOURTH YEARS (T.3 and T.4)

NOTE: Reference should be made throughout to the current I.E.E. Regulations and to relevant Codes of Practice.

1. CABLES AND BUSBARS

Comparison in detail of copper and sluminium conductors for cables and busbars including economic considerations. Rating of cables and busbars; effects of voltage-drop, temperature, grouping, coarse and close protection. Installation and termination of cables up to and including 11KV and of medium-voltage overhead lines.

2. ELECTRICAL MACHINES AND APPARATUS

Selection of correct equipment, foundation plans, mounting and lining up of machines. Types of enclosure. Methods of starting and speed control of induction, synchronous and a.c. commutator motors. Ward Leonard speed control. Application and control of mercury arc and semi-conductor rectifiers.

3. LIGHTING

A comprehensive study of the electric light sources available. Planning and design of lighting schemes for internal and external application. Lighting, fittings and polar curves. Point source calculations, inverse square law, cosine law. Luminous flux method, coefficient of utilization, depreciation and absorption factors. I.E.S. glare index.

4. HEATING

Planning of space and water heating schemes using all types of electrical heating. Calculation of heat losses and power required. Comparison with other forms of heating including economic considerations.

5. CONTROL SYSTEMS

Appreciation of open and closed loop systems; simple applications, e.g., central heating and air-conditioning systems.

6. TESTING

Tracing and remedying of faults in installations, cables, machines and associated equipment. Reporting on installation condition. Test certificates. High-voltage testing of cables and equipment. Commissioning of plant.

7. TARIFFS

Consideration of types in common use. Choice of most advantageous tariff for an installation.

8. SPECIAL INSTALLATIONS

Special installations:

(i) in explosive or hazardous situations
(ii) farm and horticultural installations
(iii) fire alarm systems including fire detection systems
(iv) temporary installations and installations on construction sites
(v) caravan sites and caravan installations
(vi) standby sources of supply and their automatic operation.

9. LIGHTING PROTECTION

Protection of buildings; bonding and earthing arrangements for protective systems.

10. CORROSION

Causes of and protection against corrosion. Cathodic protection; design and installation of systems.

11. MAINTENANCE

Installation design aspects in relation to maintenance; accessibility; planning and economics of scheculed maintenance.

12. PLANNING

Programme requirements including contractual obligations. Critical path analysis and bar-charts. Integration with other trades. Phased delivery of materials to site. Programming of labour requirements.

13. ESTIMATING AND TENDERING

Take-off and pricing of materials, plant and labour for an installation. Calculation of labour rate for a given site and for a particular ser of circumstances. Contracts and sub-contracts in common use including R.I.B.A., I.E.E./MECH.E., C.C.C./WORKS/1.

14. SAFETY

Industrial safety. Safety on sites, legal obligations (see 'Supervisor's Guide to the Construction Regulations' published by Ro.S.P.A.).
Accident prevention. Methods of dealing with and reporting site accidents.

15. SITE ADMINISTRATION

Labour relations including a working knowledge of the National Working Rule Agreement; statutory health and welfare regulations.
Specification, drawings and bills of quantities.
Dayworks and variations, methods of recording and pricing. Increased costs and site instructions. Valuation for interim payments.
Preparation of final accounts for installations.
Records and 'as fitted' drawings.

MATHEMATICAL APPLICATIONS (INSTALLATION)

FOURTH YEAR (T.4)

NOTE: The Mathematics syllabus is for guidance only. It is expected that students will cover all parts of the syllabus. In determining the sections to be covered or emphasized, consideration may be given to local inductrial requirements.

1. ELECTRICAL NETWORKS

Formation of equations involving circulating currents and Kirchoff's Laws; solution of such equations in three or more unknowns, e.g., T and π networks.

2. EXPONENTIAL VARIATIONS

Sketching and plotting of functions such as

$Y = 1 - e^{-x}$, $y = Ae^{kt}$, $v = Ve^{-t/CR}$.

Solution of simple practical problems, e.g., the rise and fall of current in inductive and capacitive circuits and the rise and fall of temperature in electrical equipment. Time constants, their meaning, determination and use.

3. MAXIMUM AND MINIMUM VALUES

Simple practical problems, e.g., maximum efficiency conditions for plant. Economic considerations, e.g., Kelvin's Law.

4. AIDS TO CALCULATION AND DATA PRESENTATION

Use of simple calculating machines. Introduction to simple computer programming and machine control. Use and explanation of simple integrating and differentiating circuits.

5. FINANCIAL AND COMMERCIAL CONSIDERATIONS

Financial records; day books for purchase and sales; cash book; journal; petty cash payment records; ledger accounts of purchase and sales. (Interpretation of a balance sheet.) Profit and loss account and trading account. Factors affecting cash flow and liquidity. Cost accounts; basic principles and relationship to financial accounts. Significance of ratios, e.g., profit to capital emplyed, profit to turnover.

TESTING METHODS AND RELIABILITY*

FOURTH YEAR (T.4)

1. The need for testing. The purpose of Specifications. British Standard Specifications, their aims and uses. Tests to verify consistency of performance and continued satisfactory functioning under specified environmental conditions. Testing of prototypes, small and large batch items. The relationship between testing, inspection, quality and reliability.

2. Testing techniques. Recording, tabulation, interpretation and analysis of results. Estimation of experimental error.

3. Instruments. Review of the applications and limitations of electrical indicating instruments; moving-coil, moving-iron, rectifier, thermal, electro-dynamic, valve-voltmeter, digital display, multi-range and multi-purpose indicating instruments. Distinction between instrument types, e.g., industrial and precision portable and switchboard. Sources of error; shunts and multipliers, the effect of frequency and wave form, the correct choice of instrument. Review of simple precautions to be observed before taking readings, e.g., zero-setting, instrument position, scale factors, checking for mechanical faults. Calibration of ammeter, voltmeter and wattmeter against precision grade instruments (note B.S. 89 recommendations).
The preparation of correction curves and calibration records.

4. Measurements. Review of the measurement of low, medium and high resistnace, including insulation resistance. Accuracy; factors affecting the choice of indicating, comparison and null methods of resistnace measurement under d.c. conditions. Checking of inductance and capacitance values using simple four-arm a.c. bridges constructed from readily available components in the Maxwell or De Sauty configurations. Factors affecting choice of detector. Setting up and use of a commercial bridge. Miniature a.c. and d.c. motor testing; use in instrumentation and control systems.

5. Logarithmic units. Bel and Decibel. The decibel as defined in B.S.204(1960). Use of logarithmic units; logarithmic calibration of instrument scales and controls. Use of logarithmic and polar graph paper.

6. Reliability. Importance of Reliability. System complexity, risks inherent in failures. Definitions. Reliability; mean time to failure; mean time between failures. Types of failure; inherent weakness; misuse; sudden, gradual, partial, complete, catastrophic and degradation failures. Periods of failure; early, constant and waer-out failure periods. The bath tub diagram. Conditions of use. Effects of vibration, exposure, etc., in the application situation environmental humidity and temperature; assessment of reliability required; professional and non-professional applications. Distribution and sampling techniques. Elementary descriptive treatment of data handling; averages; standard deviation. Normal and Poisson distributions. Sampling; confidence limits. Reliability expressed in the form $R_t = e^{-t/m}$. Installation. Effects of installation faults on reliability. Operability. Failures due to incorrect operation; basic concepts in the best presentation of information and correct positioning of controls. Maintainability. Definition; importance of high availability; basic concepts of good maintainability. Operational failures. Importance of accurate interpretation and reporting. Cost. Relationship between reliability and cost; concept of total cost.

7. Measurement of single-phase power, choice of alternative wattmeter connections, allowance for current and voltage coil losses. Extension of instrument range by use of current and voltage transformers. Precautions to be observed.

8. The measurement of electrical power, reactive volt-amperes and energy using the induction type instrument, extension of range. Accuracy check on watt-hour meter using wattmeter, stop watch and phase-shifter. Determination of inductance and capacitance by measurement of watts and volt-amperes. The measurement of power and reactive volt-ampers in 3-phase, 3-wire and 4-wire circuits with balanced and unbalanced loads. Frequency measurement using modern frequency meters, C.R.O., or C.R.O. with I.f. signal generator. Testing of synchroscopes, power-factor and phase-angle indicators.

9. Speed measurement by revolution counter and stop watch, tachometer and tachogenerator. The stroboscopic principle and its use in speed measurement. The commercial stroboscope. Comparison of methods and of accuracy. Measurement of high speeds, e.g., of very small fractional h.p. motors used in servo-mechanisms.

10. Temperature rise testing. Comparison of methods using thermo-couple, change of winding resistnace, mercury-in-glass thermometer. Embedded sensing elements. Effect of siting of sensing elements on accuracy of results.

11. Tests to obtain the overall efficiency of d.c. motor and generator, transformer and induction motor. Torque-slip curves of induction motor by brake test.

12. Recommended mechanical and electrical tests to be made on suspect equipment before connecting to supply. The C.R.O. and its use to display waveforms for voltage measurements and as a bridge detector; photographic recording.

13. Simple valve and transistor tests using commercial testing equipment. Elementary testing of simple valve and transistor amplifiers. Simple fault-finding. Measurement of voltage and power gain. Use of 1.f. signal generator and valve-voltmeter.

14. Earth continuity and bonding tests to determine the effectiveness of the earth connection. Simple fault location.

CONSUMER DISTRIBUTION SYSTEMS

FOURTH YEAR (T.4)

1. HIGH VOLTAGE SWITCHGEAR (up to and including 11KV)

   Construction, operation and comparison of oil-immersed, air-break, air and gas-blast types of circuit-breaker.

2. MEDIUM VOLTAGE SWITCHGEAR

   Characteristics and operation of high breaking capacity fusegear, air and oil-break switches and circuit-breakers, moulded case and mimiature circuit-breakers.

3. TRANSFORMERS

   Types of distribution transformers in common use, appreciation of economic and environmental factors affecting selection for various applications. Types of 3-phase connection.
   Buchholz system of protection.

4. METERING

   Systems and connections.

5. SUB-STATIONS

   Layouts including earthing systems and neutral earthing methods and arrangements. Earth electrode resistance. Protective multiple earthing. Safety and fire precautions. Health hazards.

6. PROTECTION

   Common forms of protection of consumers' installations for over-current reverse current and earth leakage including pilot systems.

7. DISCRIMINATION

   Effect of the requirement for discrimination of protection on the layout of an electrical installation.

8. RATING OF EQUIPMENT

Short circuit and time calculations on rating of equipment and circuits. Percentage reactance and impedance.

9. MEDIUM AND HIGH-VOLTAGE CONSUMERS DISTRIBUTION NETWORKS

Appreciation of and calculation of loads and fault levels at various points on consumers networks. Economic consideration of selection of high or medium voltage distribution for various applications and fault levels. Parallel operation of transformers and cables. Voltage drop within a network; regulation.

ELECTRICAL INSTALLATION TECHNICIANS THIRD YEAR

IN-PLANT PRACTICE

	DURATION IN WEEKS
1. MACHINES: A.C. & D.C. Routine maintenance of machines. Stripping down, cleaning, testing, painting (renewing insulation damaged) refitting new bearings. Undercutting of commutators after skimming, rebedding of brushes. Grinding for sliprings and rebedding brushes. Correct grade of brushes to be fitted - Mounting and lining up on new machines. Rectifiers.	5 WEEKS
2. CABLES AND BUSBARS Selection of copper and sluminium conductors for cables and busbars (including economic considerations). Rating of cables and bushers - effects of voltage - drop, temperature, grouping, coarse and close protection (the use of the I.E.E. tables). Installation and termination of cables up to and including 11KV and of medium voltage over head lines.	3 WEEKS
3. Different lighting systems and their calculations e.g. planning for internal and external.	4 WEEKS
4. SPECIAL INSTALLATIONS Explosive or hazardous situations, - farm and horticultural installations, fire alarm systems including fire detection systems - temporary installations on construction - sites. Standby sources of supply and their automatic operation, lighting protection of buildings.	8 WEEKS
TOTAL NUMBER OF WEEKS ALLOCATED	20 WEEKS

ELECTRICAL INSTALLATION TECHNICIANS FOURTH YEAR

IN-PLANT PRACTICE

	DURATION IN WEEKS
1. ESTIMATING AND TENDERING - PLANNING - SAFETY Take off a pricing of materials, plant and labour for an installation - Calculation of labour rate. Contracts and sub-contracts in common use. Programme requirements including contractual obligations. Critical path analysis and bar charts. Integration with other trades. phased delivery of materials to site - industrial safety on sites - legal obligations - accident prevention.	7 WEEKS
2. HIGH AND MEDIUM VOLTAGE SWITCHGEAR Construction, operation and comparison of oil-immersed, air and gas - blast types of circuit breakers. Familiarisation of characteristics and operation of high breaking capacity fusegear, air and oil-break switches and circuit - breakers, moulded case and miniature circuit breakers - rating of equipment. - Discrimination of protection on the layout of an installation.	8 WEEKS
3. MEDIUM AND HIGH - VOLTAGE DISTRIBUTION NETWORKS Appreciation of and calculation of loads and fault levels. Economic consideration of selecting high or medium voltage distribution. - Types of distribution transformers in common use, - economic and environmental factors affecting applications. Buchholz system of protection. Metering - systems and connections - protection, common forms of protection, over current, reverse current and earth leakage including pilot systems. Substation layouts including earthing systems and neutral earthing methods. Earth electrode resistance P.M.E. - Fire precautions - Health hazards.	8 WEEKS
TOTAL NUMBERS OF WEEKS ALLOCATED	23 WEEKS