

II - 5 工学部 機械工学科 建設機械



## CONSTRUCTION PLANT TECHNICIANS CERTIFICATE

### INTRODUCTION

1. This scheme for courses of part-time study and related examinations intended to provide broad technical qualifications for students with suitable educational background, employed in the construction plant industry to develop an ability to diagnose faults, recommend means of rectifying these faults and to test and analyse the performance of the plant after repair or modification has been completed. It is hoped therefore, that this course will help to provide technicians suitable for the more senior responsible posts in maintenance and repair workshops. In addition to the technical subjects, General Studies are included in order to develop the students ability to absorb, interpret and transmit information, whether in spoken or written form, and to contribute to their general education and personal development. The scheme has been designed to be complementary to the training and experience students will obtain in their employment.

Further explanatory notes related to the course are contained in Appendix A;

Course of Study.

2. The scheme has been devised on the assumption that normally students will attend a technical college on a part-time day or block release basis. It is in three stages. Part I (about 780 hours of Technical Studies and 52 hours of General Studies) gives a broad introduction to the theoretical and practical aspects of construction plant maintenance and is appropriate to the needs of apprentices and junior technicians who require a general understanding of the basis of their work.

Part II (about 1100 hours of Technical Studies and 78 hours of General Studies) provides for further study, and the Part III (about 320 hours of Technical Studies) is designed to enable the students on completion of his technical studies and concurrently with suitable experience, to study basic organization and administration of the three main developments within the construction plant maintenance organization, Parts, Sales and Service. This will serve as an introduction preliminary to his taking full administrative responsibilities later in his career. The Part III Certificate is Full Technological Certificate requirement.

3. The Topic of The Course are shown below:

Part I

- (a) Plant Technology
  - (b) Prime Movers Technology
  - (c) Mechanical Engineering Technology
- Practical Work (for a, b and c)  
Sketching and Drawing  
Mathematics  
Science  
Laboratory Work (see Appendix B)  
General Studies.

Part II

- (a) Plant Technology
  - (b) Prime Movers Technology
- Practical Work (for a and b)  
Sketching and Drawing  
Mathematics  
Science  
Laboratory Work (see Appendix B)  
General Studies.

Part III

- Parts Marketing and Sales  
Principles of Supervision  
Construction Practice  
Commercial Practice and Office Procedure  
The Law Relating to the Construction Plant

4. Course Work consisting of Class Work Laboratory and Practical Work and General Studies is regarded as an integral part of the course. With General Studies (see Para. I) the aim should be to allocate about 60 hours per year to them in Part I and II. The E.A.E.C. will not examine in General Studies and institutions are free to devise their own syllabuses and approach to the subject. The E.A.E.C. has published a pamphlet in which an approach to General Studies is suggested.

5. This scheme has been planned in association with subjects maintenance and repair of construction plant (620).

6. Entry To Course

Students for the courses must satisfy one of the following conditions or have reached the appropriate standard by an alternative route:

- (a) Part I
- (i) East African Certificate of Education issued by the E.A.E.C. at Ordinary Level in English, Mathematics and approved Science Subject with credit passes.
  - (ii) Part I Certificate in Maintenance and Repair Construction Plant 620 with Credit.
  - (iii) Appropriate academic ability in a mature student.
- (b) Part II
- The student must have completed 52 weeks on industrial attachment before starting the Part II.
- A pass in Part I examination Construction Plant Technician.
- A pass in Maintenance and Repair of Construction Plant 620 Part II with Credit.
- (c) Part III
- A pass in Construction Plant Technician Part II examinations.

7. Countries outside East Africa.

This scheme is available to countries outside East Africa at those institutions which have received the approval of the E.A.E.C. Application for approval of a course should be made on the appropriate form issued by the E.A.E.C.

8. The E.A.E.C., will offer an examination at the end of Part I of the course, except in cases where an institution is recognized by the Council as being capable of conducting this examination internally. Institutions wishing to conduct their own examination for Part I of the course should apply for permission to the E.A.E.C.

Part I	1025/01	Const. Plant Tech. I (Theory & Pract.)	= 3 hrs.
	1025/02	Const. Plant Tech. II(Theory & Pract.)	= 3 hrs.
	1025/03	Eng. Drawing & Maths.	= 3 hrs.
	1025/04	Mech. Eng. Science (Theory & Pract.)	= 3 hrs.

Students will not be permitted to proceed to Part II unless they have reached a satisfactory standard in the Part I examination and have met the requirements for course work as prescribed by the Part I examining body.

9. Part II examinations will be offered by the E.A.E.C. in July and December of each year, and will be conducted according to the regulations published by the E.A.E.C.

Each examination will consist of three papers:

1025/10	Const. Plant Tech. I (Theory & Pract.)	= 3 hrs.
1025/11	Const. Plant Tech. II(Theory & Pract.)	= 3 hrs.
1025/12	Eng. Drawing & Workshop Pract.	= 3 hrs.
1025/13	Mech. Eng. Science & Maths.	= 3 hrs.

10. Part III Examinations will be held in July of each year, and will consist of two papers as follows:

1025/20	Principles of Management	= 3 hrs.
1025/21	Workshop Organization and Administration	= 3 hrs.
1025/22	Commercial Practice	= 3 hrs.
1025/23	Project Work	

All Examinations will be set wholly in SI Units.

## 11. Entry for Examinations

The E.A.E.C. will not accept any entry from an individual applicant. Candidates must submit their entries through an examination centre on the prescribed form obtainable from the Centre. Entries must reach the E.A.E.C. by 30th April for July examinations, and 30th September, for December examinations.

Colleges must submit to the E.A.E.C. on the prescribed forms lists of the full names together with colleges records of all students entered by the college for each examination.

No candidate will be admitted to the examination or be eligible for a certificate unless he/she, has satisfactorily completed an approved course at a technical college or other institutions for further education. External candidates will only be accepted if they have completed the proscribed E.A.E.C. form and satisfactorily complied with the conditions required in relation to the form and have further satisfied the authorized assessors that they are capable of attempting the examination.

Late entries subject to an additional fee may be accepted at the direction of the E.A.E.C.

## 12. Records of Students Work

Records of marks awarded for Course Work must be kept by colleges for submission to the E.A.E.C. on the appropriate form in respect of each candidate entered for examinations. Laboratory and Practical Work note books must be kept and must be available for inspection by the E.A.E.C. or its examiners when called for.

## 13. Attendance and Course Work Requirements

Each candidate will be required to make at least 75% of the possible attendances in each subject, including General Studies, and will be required to complete the schedule of Class - Work, Laboratory and practical work as prescribed by the syllabus, including project work at Part III (Appendix C).

Colleges will be required to submit evidence of such marks awarded after the examination has been taken. These marks will be assessed by the E.A.E.C. as Course work. (See para. 12.)

14. English

The examination set by the E.A.E.C. will be set and answered in English though the examiners will not be allowed to assess the standard of English used by the candidates.

15. Results and Certificate

Results in the examinations as a whole will be issued in four classes and for the individual papers including course work, in eight grades. The relationship between classes and grades is:

Pass with distinction	- Grades 1 & 2
Pass with credit	- Grades 3 & 4
Pass	- Grades 5 & 6
Fail	- Grades 7 & 8

Each candidate will receive a record of performance for Part I, II & Part III giving the result in terms of class and grade.

Part I, Part II and Part III Certificates are awarded to candidates who pass all parts of the Part I, Part II and Part III, E.A.E.C. Examinations in the same examination series, and satisfy the Course Work requirements. The certificates will show the class of and also the names of the subjects passed. Students sitting for the internal C.P.T. Part I will be advised by the institution concerned of their results for the examination.

16. If during the currency of the scheme the E.A.E.C. deems it appropriate to modify the pattern of the examinations and awards, the necessary changes to the regulations will be notified to colleges in advance of their being applied.



## APPENDIX A.

### Explanatory Notes.

1. The aim of the technician's course is to study in detail the basic principles covering the design and construction of the Construction plant equipment to enable the student, with suitable concurrent industrial experience, to develop an ability to diagnose faults, recommend means of rectifying these faults and to test and analyse the performance of plant after the repair or modification has been completed.
2. The technology (a, b & c) is the main element of the course and the emphasis should be on general principles, which can be equally well applied to existing or 'conventional' components and assemblies and to new types not yet in service or even at the manufacturing and design stage, rather than on the small details of existing types or minor developments in design which can rapidly become out-dated.
3. The Practical Work should illustrate the technology syllabus and be closely related to the student's industrial experience. Sketching and drawing should provide the background for understanding basic principles of mechanisms and their application to the design and manufacture of construction plant components, the layout and assembly of control linkages and the use of vector diagrams in analysing the motions and forces arising.
4. The aim of the related Mathematics syllabus is to develop the basic principles upon which depend the calculations a technician may be expected to use or understand.
5. The Science syllabus is closely related to the programme of Laboratory Work.
6. Throughout the course every opportunity should be taken to apply the related studies to construction plant vehicle problems but the teaching of all subjects should not be taken beyond the depth necessary to support the construction plant technology.

## APPENDIX B.

### Guide to Preparation of College Work

1. Each student must record, in time order, tasks performed in the workshop and the experiments should be entered in a "List of Contents", preferably at the front of the book. This list should be kept from the start in chronological order and the entries should be indexed to distinguish workshop tasks from laboratory experiments and one year's work from another.
2. It is recommended that the practical record of any task or experiment should include:
  - a) the date of performing the job
  - b) the title of the job (which should be sufficiently extended to eliminate the need for a separate statement of the purpose or object of the job).
  - c) a simple diagram of the experimental arrangement on which could be marked the identification numbers of all 'significant equipment' (so eliminating the need for a separate list of apparatus).
  - d) a brief statement of the method used.
  - e) a presentation in simple numerical, tabular and/or graphical form of observed and derived results.
  - f) a brief explanation of the results (students should be stopped from writing more verbal descriptions of results already fully presented in numerical, tabular, or graphical form).
3. Students should be required to write formal reports on at least one workshop task and laboratory experiment annually selected by them out of a nominated list from the year's total.

## APPENDIX C.

### Projects

1. In Part III, each candidate is required to complete a written project during his course. The project should be on any relevant aspect of the construction plant repair industry covered in the Part III syllabus and should entail a total of approximately 25 hours of work by each student in addition to the 500 hours envisaged for the course. The project will be assessed by the E.A.E.C. and such assessment will be used in the determination of examination results by the E.A.E.C. A list of projects should be submitted to the E.A.E.C. by the centre during the second term of the course.

The E.A.E.C. reserves the right to call for candidates written accounts of their projects, when completed, and to appoint visiting assessors to assist in establishing uniform standards.

A list of specimen approved project titles is available to colleges on request.

2. Local Examinations Officers are required to submit on the prescribed form details of candidates' assessments at the end of the course.
3. Each external candidate must comply with the conditions detailed in para II of the regulations for the course, and in addition must state the title of his proposed project for approval by a centre. This project will be assessed by the centre and submitted through the Local Examinations Officer on the prescribed form.

## CONSTRUCTION PLANT TECHNICIANS' PART I

### TECHNOLOGY

#### PRIME MOVERS

The main components of the I. C. engine. The principle of operation of the C. I. and S. I. engines on the four and two stroke cycles. Elementary reasons for the use of more than one cylinder. Consideration of typical engine layouts, arrangement of cylinders and crank throwers. Common valve arrangements and mechanisms.

Function of the main items of electrical equipment. The action of a coil ignition system and magneto.

The petrol supply system (layout). The simple carburettor.

The layout of the C. I. fuel system. The need for filtration and bleeding.

The thermo syphon water cooling system, use of water pump.

The single plate friction clutch, construction and operation. Characteristics of the I. C. engine which demands use of a clutch.

The gearbox. Engine and load characteristics which demand its use. Sliding mesh and constant mesh gearboxes.

Propellor shaft, universal and sliding joints (excluding constant velocity joints).

Final drive. Types of drive used in wheeled plant and reasons. The transmission of the drive through differential gears, reasons for having the differential gear and the action of the diff. Construction and action of a differential lock.

Methods of axle shaft support i.e. semi, three quarter and fully floating.

The front axle and steering system. Conditions necessary for true rolling of all wheels. Simple beam axle with Ackermann linkage. Steering gearbox.

Types of braking systems in common use. Drum and disc brakes.

Lamps used in plant vehicles, aligning and focusing, anti-dazzle devices. Types of cables, connectors and fuses with reference to current carrying capacity. Lead acid batteries, brief description of plates, separators and containers. Composition of and preparation of electrolyte. Use of hydrometer. Common battery faults. Testing and care of lead acid batteries. Effect of high and low temperature on charging and discharging.

## CONSTRUCTION PLANT TECHNICIANS' PART I

### TECHNOLOGY

#### PRIME MOVERS

Engine construction. Cylinder blocks, head and gaskets. Wet and dry liners. Pistons, types of rings, location and clearances, gudgeon pins and their location. Connecting rods and bearings, crankshafts. Overhead camshafts. Types of combustion chamber on C. I. Engine. Comparison of C. I. and S. I. Engines.

S. I. engines fuel system. Types of petrol pumps. Types of carburettors, methods of controlling mixture strength, air bleed, compound jet, variable choke, cold starting, slow running acceleration and economy devices.

C. I. engines fuel injection equipment. In line fuel injection pump, construction and operation. Control of engine speed and power by means of a simple governor. Phasing and calibrating. Injectors and nozzles. Fuel lift pumps and fuel filters.

Lubrication. Use of force feed lubrication. Types of oil pumps, relief valve, and oil filters. Oil gauges and warning lights. Dry sump lubrication. Properties of lubricants. S. A. F. classification. Causes and effects of excessive oil consumption.

Cooling systems. Air cooled engines. Pressured water cooling systems, detail of water pump, radiator pressure caps, and thermostats.

Nickel iron alkaline batteries. Advance and retard mechanisms. Detail of sparking plugs and their selection. Ignition timing. Simple starter motors and inertia drives. D. C. generators and regulators. Including cut-out.

Detail of clutch centre plates and friction materials.

Principles underlying castor, camber, wheel alignment and king pin inclination.

Brakes. Leading and trailing shoes. Friction lining materials. Brake phase. Layout of hydraulic system and detail of master cylinder and wheel cylinders.

## CONSTRUCTION PLANT TECHNICIAN SYLLABUS PART I

### TECHNOLOGY

#### PLANT

An appreciation of all types of construction plant that exists i.e. small plant, water pumps. Diaphragm and centrifugal drum and pan mixers, vibrators, rollers tampers and pokers. Heavy plant, primo movers, tanker trucks, front and various, loaders, scrapers, graders entrenching machines, concrete mixers, asphalt finishers, asphalt kettles, fork lifts, earth movers, earth augers, motorised saws and compressers.

Layout of transmission systems in vehicles and plant.

Principle of dog clutch cone clutch, expanding shoe centrifugal clutch and control mechanisms and adjustments.

Common methods of suspension used in plant. Live and dead axles, elliptical and coil springs and torsion bars. Methods of damping.

Wheels and tyres, construction and size. Selection for use, fitting, wet and dry ballasting.

Brakers, mechanical systems, band brake.

Hydraulics. Principle of operation of simple circuits. Function of pump, motor, reservoir, filter, relief valve, directional control valve and cylinders in simple circuits. Filling and bleeding.

Compressors. Types of rotary and reciprocating pneumatic tools used, their construction and operation, importance of filters, strainers and lubricators.

Starting systems. Types of torque limiting clutches. Switches and protective devices, construction of manual and relay controlled switches, overhead devices and circuit breakers, Donkey Engines and compressed air starting systems.

Hydraulics. Types of pumps and motors, valves, cylinders and methods of scaling, types of scales, filters and strainers.

Ridged and flexible pipes and their fittings. Properties of fluid, avoidance and detection of contamination.

Fluid transmission. Fluid couplings i. e. fluid flywheel and torque convertor, their construction and operation.

Simple treatment of power shift gearbox.

## CONSTRUCTION PLANT TECHNICIANS' COURSE PART I

### MECHANICAL ENGINEERING

General workshop regulations, legal requirements relating to safety. Basic safety precautions on machinery, lifting tackle, jacking etc.

Common fitting tools care and use. Marking out tools care and use. Properties of common irons and steels, effect of properties on uses. Identification by workshop methods. Basic cutting action and tool angles for bench tools. Methods of sharpening. The care and use of twist drills. Types of screw threads, and uses in plant. Use of Screw thread tables. Hand cutting screw threads.

Methods of measurement in the workshop. Micrometer and vernier scales; action, care and use of internal and external micrometers; care and use of vernier caliper, high and depth gauges, cylinder bore gauges, telescopic gauge and Go-no-Go gauges.

An appreciation of machine shop processes = Tools as used in turning. The use of the centre lathe for turning between centres and simple chuck and face plate work. Simple grinding and milling operations.

Solders and fluxes and their uses; composition of common solders; common methods of soldering. Precautions in the repair of fuel tanks.

Welding techniques; safety regulations and precautions relating to gas welding. Application of welding and cutting techniques to plant repairs. Gas welding cast iron by fusion welding and bronze welding.

Electric Arc holding, safety regulations and precautions. AC and DC current and voltages, choice of electrodes. Weld testing.

Air compressors and tools. Elements of workshop compressed air system. Types of compressors, rating, pressure control, cooling servicing and fault diagnosing, valve unloader, intercooler, receivers, filter and water traps, pipe, hoses and connectors. Lubrication, maintenance, safety regulations.

Lifting gear, hoist and crane type winches and pile drives driving and braking and braking mechanisms. Mechanical, hydraulic and pneumatic operating linkages. Steel and fibre ropes, care, maintenance and inspection, protection and storage. Sling spreaders and rope anchors. Sheer legs, derricks and gatries. Lifting jacks. Types of cranes in common use. Safety devices and factors of safety.

## CONSTRUCTION PLANT TECHNICIANS' SYLLABUS PART I

### PRIME MOVERS PRACTICAL

Dismantling a single cylinder, four stroke engine and a two stroke S. I. and C. I., engines. Noting the sequence of operations and function of each part. Assemble of the same engines. Inspection of valve arrangements and operating mechanisms. Setting tappet clearances. Inspection of the main items of electrical equipment, including wiring details and connections of typical coil ignition system. Dismantling and re-assembling a distributor and magneto. Cleaning and adjusting spark plugs and distributor contact gaps to specification. Inspection of a typical fuel supply system for an S. I. engine. Inspection of a typical fuel supply system for a C. I. engine and bleeding of this system.

Dismantling and re-assembling the cooling system of a four cylinder engine noting the functions of the radiator, thermostat, circulating pump and connections.

Dismantling and re-assembling a single plate clutch, noting sequence of operations and the name and functions of each part. Particular reference should be made to provisions for adjustment.

Dismantling of three or four speed gear box of both the sliding mesh and constant mesh types, noting the sequence of operation and the name and functions of each part. Particular reference should be made to the methods of engaging gears and any provisions for adjustments. Re-assemble of the same gearbox.

Dismantling universal joints noting the sequence of operations and functions of each part. Checking an open type propeller shaft for straightness and correct alignment of universal joints.

Dismantling a rear axle noting the sequence of operations and the name and function of each part. Assembly of the same rear axle. Inspection of alternative types of final drive fears with particular reference to bearing arrangements and provision for adjustment. Inspection of methods of axle shaft support. Inspection of a differential lock;

Dismantling and re-assembling of a steering box noting the sequence of operations and the name and function of each part with special reference to provisions for adjustment.



Inspection of the braking system. Dismantling the components, noting the name and function of each part. (Both drum and disc brakes). Re-assembling the brakes with particular reference to provision for adjustment. Examination of various types of bulbs and vehicle lamps. Provision for alignment of head lamps. Dismantling, examining and re-building a demonstration lead acid cell noting the function of each part and the material of which it is made. The use of values of specific gravity and voltage to assess the state of charge and general condition of cells.

## CONSTRUCTION PLANT TECHNICIANS' SYLLABUS PART I

### PRIME MOVERS PRACTICAL.

Complete dismantling and re-assembly of an engine to include the following; Examination of all parts listed under technology. Valve grinding and valve seat replacing. Checking alignment of connecting rods and rectification. Measurement and gauging of cylinder bores, crank shafts, cam shafts and bearings. Correct selection of pistons, fitting of rings. Setting up and boring cylinders to specified oversize.

Stripping C. I. engine for inspection. Re-assembly. Bleeding the injection system. Timing of fuel pumps. Checking if injectors are functioning correctly whilst the engine is running. Checking cylinder compression. Examining typical engine lubricating systems. Pressure testing with oil. Dismantling, examining, re-assembling and testing oil pumps of various types for satisfactory operation. Examination of full flow and by pass types of oil filters. Checking of oil pressure relief and by pass valves. Checking of oil pressure gauges.

Reconditioning of water pumps. Pressure test of cooling system for leaks. Simple flow tests through a radiator as a means of determining internal condition. Testing radiator pressure caps for satisfactory operation. Checking thermostats.

Dismantling, inspecting, and re-assembling of common types of mechanical and electrical diaphragm pumps. Testing for satisfactory operation. Dismantling, inspecting and re-assembling a variable choke and a constant choke carburettor, noting any special features and adjustments.

Examination and test of a complete coil ignition system using modern analyzing equipment. Reconditioning distributors. Timing to engine and reconnecting leads. Testing faulty spark plugs in a pressure chamber in conjunction with the oscilloscope.

Overhaul of inertia engagement starters followed by correct testing procedures. Dismantling fuel injection pumps (in line), checking components, re-assembly, phasing and calibrating. Dismantling various injectors, reconditioning and testing. Examination of various types of fuel filters. Examining a single plate clutch assembly and its details. Testing of springs. Assembly and adjustment of a clutch jig.

Checking of wheel alignment, caster, camber, and K. P. I. Measuring turning angles as a means of insuring correct setting of steering linkages. Dismantling and re-assembling of brakes, bleeding of hydraulic systems. Examination and testing of D. C. generators. Examination, testing and adjustment of output control units for the D. C. generator.

#### CONSTRUCTION PLANT TECHNICIANS' COURSE PART I

##### PLANT PRACTICAL (APPLIED PLANT TECHNOLOGY)

Inspection of the layout and the main components of all types of construction plant equipment.

Inspection of the layout and the main components of transmission systems in vehicles and plant.

Dismantling and re-assembling of a dog clutch, cone clutch, expanding shoe clutch and control mechanisms, and necessary adjustments.

Dismantling and re-assembling of common suspension system used in plant. Removing and replacing types and wet and dry ballasting of wheels. Dismantling and re-assembling of mechanical brake systems including the band brake and making the necessary adjustments.

Dismantling, inspect and re-assemble simple hydraulic circuits to include directional control valves. Examination of faults. Examination of filters. Dismantle, inspect and re-assemble a pressure relief valve. Dismantle and inspect a hydraulic system on an item of construction plant, re-assembling and bleeding the system to remove air locks stressing the importance of absolute cleanliness.

Inspection of compressors. Dismantling and re-assembling of rotary and reciprocating tools used with compressors.

Inspection of starting systems. Dismantling and assembling of torque limiting clutches, switches and protective devices, overload devices and circuit breakers.

Inspect hydraulic pumps, motors, cylinders and rams. Inspect and establish the hydraulic circuit on an item of contractors plant with particular reference to safety and cleanliness. Correct assembly of seals and glands.

Inspection of a simple air system. Dismantling and inspect a compressor. Air, lines. Fitting new couplings and testing, stressing cleanliness and safety. Demonstrate the detrimental effects of dirty in a pneumatic tool clean and re-assemble.

Flaring of hydraulic pipes. Fitting of pipe unions. Preparation of flexible hose and attachment of re-usable and fitting.

Dismantling and assembling of a fluid fly wheel, noting its action, type of fluid used and its movement through the vanes and passages. The faults and maintenance of a fluid fly wheel.

Examination of the components of a torque convertor noting their action. Type of fluid and its movement through the torque convertor. Inspection of the three stage torque convertor. Routing maintenance stock. Recondition of a faulty torque convertor.

Inspect the track and track drive systems on a tracked vehicle. Method of adjustment, replacement. Lubrication and maintenance of track running gear.

## CONSTRUCTION PLANT TECHNICIANS' SYLLABUS PART 1

### MECHANICAL ENGINEERING PRACTICAL (APPLIED TECHNOLOGY)

Common fitting tools, their care and use. Methods of sharpening bench tools. Grinding machine safety precautions. Instruction in simple marking out; use of measuring instruments including micrometers (internal and external) vernier caliper, height and depth gauges, cylinder bore gauges, telescopic gauges.

Use of powered hand tools electric and pneumatic.  
Simple exercises on marking out, drilling and drawing of holes use of taps, stocks and dies.

Workshop tests to identify common irons and steels and to show their physical properties.

Use of the centre lathe for turning between centres, simple chuck and face plate work.

Simple grinding and milling operations.  
Soft and hard soldering. Joints and patches in sheet metal, nipples on steel and copper pipes. Making, insulating and finishing a soldered joint in electric cables.  
Repair of fuel tanks.

Use of gas welding equipment, depositing straight beads of weld metal. Butt, fillet and lap welds on mild steel plates.  
Flame cutting. Gas welding of cast iron by fusion and bronze welding.

Use of arc welding equipment. Selection of current and voltages, choice of electrodes, weld testing, spot welding.  
Dismantling and assembling of compressors. Servicing and fault diagnosing, inspection of valve unloader, intercooler, receivers, filters and water traps, pipes, hoses and connectors. Lubrication and maintenance.  
Inspection of the layout of hoist and crane type winches.  
Dismantling and assembling driving and braking mechanisms.  
Dismantling and assembling and adjusting of mechanical, hydraulic and pneumatic operating linkages.

Anchoring and threading of rope. The inspection, fault diagnosis and fault rectification of a rope layout on items of plant.  
Inspection and use of sheer legs, dericks, gantries, lifting jacks and types of cranes in common use.

## CONSTRUCTION PLANT TECHNICIANS' SYLLABUS PART I

### DRAWING AND SKETCHING

Interpretation of simple engineering drawings; principles of projection and their use in simple sketches of solids; use of line diagrams.

The purpose and use of dimensions in sketches and drawings.

Sketching and drawing of simple components in orthographic projection (first and third angle) with dimensions.

Introduction to limits and tolerances and their inclusion in the dimensioning of sketches and drawings.

Reading of exploded and sectional views of components and assemblies.

Geometrical constructions related to marking out problems and to linkages and mechanisms covered in plant technology.

Application of the principles of sketching and drawing to the production of engine, gear box, rear axle, braking, steering and suspension layouts and to dimensioned sketches of the components of the systems, including some sectional views and simple sub assemblies.

Line diagrams, illustrating fuel supply systems, electrical circuits, power paths in transmission systems, steering and suspension linkages. Conventional representation (B. S. 308 drawing office practice) of forms and components in common use in plant e.g. screw threads, springs, gear wheels, ball bearings.

Electrical symbols and diagrams to B. S. 3939.

Welding symbols to B. S. 499.

Use of cross sectional views. Applications to the units dealt with in plant technology with particular reference to engine cylinders, pistons, connecting rods and valve gears; carburettor details and fuel pumps; water pumps and thermostats; lubrication components and details.

Sketches and drawing of electrical components.

Sketches and drawings of various types of clutches and operating mechanisms; gear boxes and steering boxes.

Line diagrams illustrating engine lubrication systems; valve arrangement and cam shaft drives; fuel supply systems; cooling systems; electrical circuits.

Geometrical diagrams to show the ideal conditions for steered wheels to give true steering. The layout of the Ackermann linkage.

Introduction to the plotting of loci of piston movement in rotation to crank angle displacement; valve timing diagrams and the construction of an ellipse.

Introduction to the triangle and parallelogram of forces and simple vector diagrams.

## CONSTRUCTION PLANT TECHNICIANS' SYLLABUS PART I

### MATHEMATICS

Volume. Weight. Capacity. Decimalisation. Percentages. Ratios. Direct, indirect and joint proportion.

Expressions, equations and formulae. Solution of simple equations. Straight line graphs.

Silultaneous equations and solution by graphical means. Indices and logarithms.

Ratio in geometry. The sine, cosine and tangent. Use of trig tables. Solution of right angled triangles. Area of triangle in the form  $\frac{1}{2} bc \sin A$ . Transportation of formulae. Use of logs solving transposed equations. Slide rule. Square roots. Reciprocals of number.

Volumes and weights of rectangular solids and cylinders.

Introduction to tolerances and clearance and interference fits. Limits of sizes with associated calculations.

The principles of the micrometer and of vernier scales.

Introduction to graphs with applications to experimental readings and tabulated information such as valve lift against crank shaft angle, speed against time from tabulated figures for vehicle performance tests.

Ratio and proportion in geometry. Intercept theorem. The circle and cylinder. Ratio of circumference to a diameter. Area of a circle. Surface area of a cylinder. Circular measure. Use of tables to convert radins to degrees. Length of area of circle. Area of sector. Area of segment of circle. Measurement problems.

Quadratic equations. Harder straight line graphs. The parabola and hyperbola. Slope of tangent at a point.

Graphical problems appropriate to the course. Area under a curve. Hid ordinate rule and simpsons rule. Intersecting cords of a circle. Rectangle problems. Measurement of uniform cross section.

The sine and cosine rules for solution of triangles.

## CONSTRUCTION PLANT TECHNICIANS' SYLLABUS PART I

### ENGINEERING SCIENCE

#### HEAT AND PROPERTIES OF MATTER

Nature of heat, conduction, convection and radiation.  
Measurement of temperature, use of mercury in glass thermometers.  
Quantity of heat and units of measurement. Calculations of specific heat, including simple heat energy lost or gained.  
Expansion and contraction of solids, liquids and gasses when heated and cooled. Coefficient of linear expansion.

Simple treatment of the relationship between pressure, volume and temperature of gasses in the combustion process of the C. I. engine, absolute pressure.

Change of state, melting and solidification, evaporation and condensation. Simple explanation of formation of steam at a constant pressure, simple treatment of humidity. Comparison of melting point of common metals.

Freezing and boiling points of water, fuel oil, petrol, anti-freeze solutions and electrolytes.

Relative density and density of solids and liquids.

Simple concepts of the discharge of liquids and air through pipes and orifices due to pressure differences. Simple transmission of force, pressure, and energy by a fluid. The hydraulic ram and press.  
Factors affecting fluid flow such as viscosity and temperature.

Effect of air in lines.

#### MECHANICS'

The effects of a force in stretching, compressing, bending, twisting and shearing. The Newton unit of force. The joule unit of energy.  
Moment of a force about a point or an axis. The lever.  
Principle of moments as applied to plant and equipment.  
Concept of torque.

The simple machine, movement ratio, force ratio and torque ratio.  
Efficiency as a ratio of work output to work input.

Simple machine calculations on pulleys, gear, screw, bolt, chain drives and gearboxes, clutch and other operating mechanisms.  
Work done by a constant torque. The watt unit of power.  
Simple traction power. Graphical representation of work and power as used in lifting operations.

The relationship between revs per second and peripheral speed with practical applications. Graphical representation of a force.  
Resultance of two forces acting at a point. Resolution of a force into two components at right angles to each other.  
Examples based on contractors plant and machine.

Simple cases of direct shear, tensile, and compressive stress and strain, effects of length and area of cross section.  
Safety factor and its calculation.

Friction and its effects, useful and wasteful friction for different materials. Elementary treatment of dry, boundary and fluid friction.  
Effects of lubrication. The S. R. E. system.

The centre of gravity of regular shapes and solids and plain figures.  
Introduction to stable and unstable equilibrium.



## CONSTRUCTION PLANT TECHNICIANS' SYLLABUSES PART I

### ENGINEERING SCIENCE

#### MATERIALS

Further treatment of the effects of loads on structural members.  
Quantitative treatment of tension, compression, single and double shear, Hooke's Law and modulus of elasticity and rigidity.  
The difference between the elastic and permanent deformation.  
Introduction to simple bending moments, treatment limited to simply supported beams and cantilevers.

#### MECHANICS'

Effect on ground pressure of size of track or area of tyre in contact.  
Moment of a force as applied to straight and cranked levers.  
Qualitative treatment and pictorial representation of the compound lever and parallel forces. Couples. Work done by a variable force, energy, and potential energy. Friction torque in bearings, clutches and brakes. Heat generated and power lost in friction. Machines; force ratio, movement ratio and mechanical efficiency as applied to the crown wheel and differential axle, screw and hydraulic jack, geared winch and plant mechanisms. Simple and compound gearing as used in construction plant. Velocity and acceleration, velocity vectors, graphical representation. The action of leaf and coil springs.

#### FLUID MECHANICS'

Pascal's Law. Relationship between pressure, force and area.  
Pressure head. Flow of fluid through pipes; simple treatment ( $q = av$ ).

#### LUBRICATION

Properties of a lubricant and their variation with temperature.  
Viscosity index. Simple treatment of the theory of lubrication.  
Additives. Oils and greases in common use.

#### HEAT

Comparisons of the specific heats of common materials (including air and water with particular reference to cooling media).  
Meaning of absolute pressure and temperature. Quantitative relationship between pressure, volume, and temperature of a gas  $\frac{PV}{T}$  relationship only.

The specific heat of a gas under constant pressure and constant volume conditions.

### HEAT ENGINE

Cycles of operation; constant volume and constant pressure cycles, their relationship to S. I. and C. I. engines. Testing of S. I. and C. I. engines for torque and brake power. Characteristic brake power and torque curves. Relationship between torque and brake power. The effect of ambient temperature and barometric pressure on engine output. Factors governing volumetric efficiency and power output.

### COMBUSTION

The combustion process in C. I. and S. I. engines. Causes and effects of detonation; pre-ignition and diesel knock. Cetane and Cetane rating of fuel.

### SIMPLE CHEMISTRY

Difference between elements, compounds mixtures and alloys. The distinction between atoms and molecules and between physical and chemical changes. The composition of the air, simple treatment of oxidation. Elementary treatment of the chemical reactions involved in the combustion of carbon, hydrogen and sulphur. Fuel of S. I. and C. I. engines, their properties and composition, calorific value. Volatility, flash point and specific gravity. Effects of variation in air/fuel ratios on the performance of S. I. and C. I. engines; its side effects on engine components such as valves, cylinder walls, spark plugs and injectors.

### SCIENCE PRACTICAL

Experiment to show relative conductivity of metals.

Experiment to show convection and radiation.

Experiment to show different rates of expansion of different metals.

Experiment to show effect of temperature on (a) the volume, (b) the pressure of a quantity of air.

Experiment to determine the melting points of ice, wax and solders and low melting point alloys with observation of thermal and appearance changes.

Experiments on relative densities of liquids and solids.

Experiments using dial gauges to show the types of strain produced by different loadings and the difference between elastic and permanent deformation.

Experiments to show that discharge of water through pipes and orifices varies with pressure and pressure head.

Experiments on straight and bell crank levers.

Experiments with wheel to show relationship between linear and angular speeds.

Experiments on various gearboxes to measure movement ratios, force ratios and torque ratios.

Experiments to demonstrate addition and resolution of forces and the relationship between three forces in equilibrium acting at a point.

Friction experiments to include metal to metal, brake lining to metal, effect of oil film in each case.

Experiments to demonstrate the parts played by friction in transmitting forces and torques in clutches and belt drives.

(At least 12 experiments to be performed each term).

#### SCIENCE PRACTICAL

Simple tests on related materials to show the effects of tension, shear and compressive loads.

Boyle's and Charles's Law experiments. Experimental determination of swept volume, clearance volume and compression ratio.

Oil viscosity tests of various lubricants, using an orifice type of viscometer.

Specific heat experiments.

The determination of the calorific value and flash point of a typical hydro-carbon fuel.

Testing condensers for capacitance and insulation. Testing the circuits of a coil ignition system adjustable test gaps. Use of a rotating gap to show the effect of the centrifugal advance mechanisms.

Measurement of the locked torque and current of a starter motor, the voltage drop across the switch, leads and brushes, and in the battery itself. Observation of the variation of current during an actual engine starting process.

Screw jack and simple machine experiments. Test on a vehicle to ascertain the overhaul ratio between the engine and the road wheels in various gears.

Simple force board experiments.

Simple beam reaction experiments. Experiments to show the relationship between the force exerted on the brake pedal and the force developed at the brake shoes. Demonstration to show the effect of braking on the front wheels, on the rear wheels and on all four wheels.

Use of dynamometer to determine torque, brake power and brake mean effective pressure.

Specific fuel consumption tests to determine the thermal efficiency of both S. I. and C. I. engines.

#### ELECTRICITY

Electrical units; the volt, amperes ohm; their relationship; conductors, insulators and resistors.

Series and parallel methods of circuit connection. Fuses their purpose and rating. The earth return and insulated return system.

Effects of an electric current; heating, chemical and magnetic.

Simple qualitative treatment of electro magnetic induction.

#### LABORATORY

Build up of series and parallel circuits, measuring all voltages and currents. Experiments to show the effects of an electric current.

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Cells, primary and secondary. Composition of electrolyte and the variation of specific gravity with the state of charge.

Battery capacity; the ampere hour.

Relationship between E. M. F. potential difference, current and resistance in the simple direct current electric circuit. Volts and amperes, their measurement by simple meters.

Use of Ohms Law; voltage drop in conductors; resistors in series and parallel and determination of effective resistance.

LABORATORY

Experiments on primary and secondary cells. Mixing electrolyte.  
Proving Ohms Law.

.....

Effect of length, cross sectional area, material and temperature on a  
conductors resistance; the relationship between current, voltage, and  
power. Permanent magnetics; magnetic field round a conductor; a coil  
and a solenoid; force acting on a current carrying conductor in a magnetic  
field.

LABORATORY

Measurement of resistances of various conductors. Experiments involving  
magnetism i.e. solenoids, coils etc.

.....

Principles of the generator and electric motor (qualitative treatment  
only).

## CONSTRUCTION PLANT TECHNICIANS' PART II

### PRIME MOVERS

3 phase of Combustion in a C. I. engine, importance of Swirl and Turbulence. Engines. Combustion chamber shapes including shape of piston crowns in both S. I. and C. I. engines. Piston rings, special types. Crankshaft dampers, action and mounting. Attachment of wheel, timing gear and pulleys. Static and dynamic crankshaft balancing.

Pressure charging, types of superchargers including the turbo charger and use in S. I. and C. I. four and two stroke engines. Testing and checking of superchargers. Starting and shut down procedures.

Fuel injection equipment. Mechanical, hydraulic and pneumatic types of governors. Correct adjustment of pump stops. Distributor type fuel injection pump, construction, action and operating characteristics. Cold start devices for C. I. engines, heater plugs, decompressors, either spray, induction manifold heaters.

Heavy duty starter motors.

Cooling systems pressurised and scaled. Temperature gauges.

Coil ignition systems. Theory of electro magnetic induction. Influence of dwell angle on coil performance.

Clutches. Diaphragm spring, multi plate and centrifugal clutches.

Epicyclic gears. Simple treatment on automatic gearboxes and transmission reduction gears.

Constant velocity joints.

Worm and worm wheel final drive, multi drive axles, four wheel drive vehicles.

Lubricates. Specification of oils and greases for special purposes for engines and transmissions. Types of additives and reasons for their uses.

Pneumatic and hydraulic power steering systems.

Brakes. Use of booster devices and pressure limiting valves in hydraulic systems.

A. C. generators, their construction and operation. Regulators in use with A. C. generators including transistorised.

## CONSTRUCTION PLANT TECHNICIANS' PART II

### PRIME MOVERS

Engines. Factors affecting the layout of manifolds, induction and exhaust systems and constructional details and theory of operation.  
Air cleaners and silencers.

Rotor (Wankel) type engine.

Operating principles of hydraulic and mechanical systems in automatic gearboxes.

Brakes. Servo assisted brakes, continuous flow hydraulic type, suspended vacuum and vacuum assisted.

Compressed air brakes including detail of components i.e. compressor, receiver, valves and actuators.

Auxiliary. Brakes, eddy current, hydraulic and exhaust types, fail safe, air, braking system, rubber and air suspension systems.

Final drives. Limited slip differentials. Two speed and double reduction rear axles.

## CONSTRUCTION PLANT TECHNICIANS' PART II

### TECHNOLOGY

#### PLANT

Crawler tractors, their transmission and steering systems.  
Track laying gear, types of track, frames, idler sprockets, types of track pad, methods of track adjustments, servicing and maintenance requirements. Conditions affecting choice of track pads.

Hydraulics. Multiple pump circuits as used on plant. Hydraulic drive system e.g. winches, power take offs etc. Commercial testing equipment including flow motors.

Fluid transmission. Multi stage torque converter. Fluid transmission oil and cooling systems. Hydraulic drive systems, construction and operation.

Combined front and rear axle steering systems.

Plant vehicles. The constructional features, power trans, steering and braking systems of loaders, excavators, rollers, scrapers, - dozers and graders. Blades, buckets and lifting mechanisms.

Articulated and non-articulated trailer couplings. Fifth wheel and automatic arrangement, anti jack knife devices, automatic lubrication systems.

Selection for an efficient operation of plant. Practical considerations involved, costs, performance, site conditions, type and size of plant, standardization of plant operated, the work programme. Introduction to soil mechanics as applicable to plant operation.

The constructional features, power train, steering and braking layouts of entrenching machines, asphalt finishers, earth augers, motorized saws, compressors, concrete mixers.

## CONSTRUCTION PLANT TECHNICIANS' SYLLABUSES PART II

### PRIME MOVERS PRACTICAL

Examining of engine parts with special reference to those that have failed or proved faulty in service.

Techniques of fitting valve guides, seat inserts and cylinder liners.

Opening up and examining a crank shaft damper.

Examination of super charges.

Practical testing of mechanical and vacuum type governors on in-line pumps.

Examination of a distributor type pump, including testing on a suitable pump test bench.

Examination of cold starting devices.

Examination of pressurized and sealed cooling systems.

Examination of heavy duty starter motors.

Examination of various clutches. Adjustment of operating controls where applicable.

Examination of constant velocity joints.



Dismantling worm and worm wheel finally drives, multi drive axles and four wheel drive transmission systems. Re-assembling with the necessary adjustments.

Dismantling, examining, rebuilding and adjusting a power assisted steering unit of both the hydraulic and pneumatic types.

Examination of hydraulic brake booster devices and pressure limited valves.

Dismantling, examination and assembling A. C. generators. Voltage adjustments where necessary.

Examining manifolds and exhaust systems with special regard to layout and arrangement for efficient functioning.

Internal examination of automatic gear boxes with the practical testing of at least one type.

Dismantling, examining and re-assembling servo assisted brake units, power operated brake systems with special reference to servicing and any special equipment required. Inspection of an exhaust braking unit, also Eddy current and hydraulic types.

Examination of rubber, air and liquid suspension units with special reference to servicing and any special equipment required.

Inspection and demonstration of the action of a limited slip differential.

Examination of a two speed axle and a double reduction axle with special attention to provisions for adjustments of controls.

Examination and testing of a transistorized ignition system.

#### PLANT PRACTICE: (APPLIED PLANT TECHNOLOGY)

Examining hydraulic multiple pump circuits as used on plant.

Dismantling, inspecting and re-assembling the components of these circuits.

Dismantling, inspecting and re-assembling and testing hydraulic drive systems i.e. winches, power take offs etc. Use of commercial testing equipment including flow meters.

Dismantling, inspection and assembling a multi stage torque convertor.

Dismantling, inspection and assembling of a hydraulic drive system.

Inspection of a front and rear axle steering system.

The dismantling of a complete transmission system on a track type of vehicle.

Inspection of components for wear, visually and by measurement; re-building of the transmission; alignment of drive sprockets.

Inspection and maintenance procedure. Fault diagnosis and rectification.

Examination, dismantling and assembling of steering and braking systems as used in various plant vehicles.

Machining. Cylinder boring. Crank shaft grinding. Brake drum and brake disc reconditioning. Reconditioning of track running gear.

Examination and maintenance procedures on couplings for articulated and non articulated trailers, anti jack knife devices and automatic lubrication systems.

Dismantling and assembling the power train, steering and braking layouts of entrenching machines, asphalt finishers, earth augers, motorized saws, compressors, concrete mixers etc.

Routine servicing.

The selection of plant on the work site for efficient operation.

### DRAWING & SKETCHING

Introduction to isometric projection as a basis for sketching component parts in good proportion and for the preparation of pictorial views from drawings in orthographic projection.

Geometrical construction related to perpendiculars, angles, chords tangents and arcs in the drawing of profiles and templates.

Gear tooth profiles; construction of the involute curve (using tracing paper).

Standard gear wheel nomenclature, the pitch circle, diametral and module pitch, addendum and pressure angles.

Construction of typical cam profile for flat and curved followers.

Sketches and drawings related to the work in plant technology with particular reference to layout drawings and sectional views showing main design features, component construction and assembly relating to C. I. engines, fuel injection pumps, injectors and nozzles; dynamos and alternators; steering systems incorporating a power assisted circuit; final drive systems using heavy plant vehicles.

Sketching and drawings of typical plant vehicle layouts.

Hydraulic circuits and hydraulic symbols.

Transmission paths in track laying vehicles, methods of steering the track frame and its components.

Sketches and drawings of special tools, clamping devices, testing equipment to show methods of construction and use; principles of geometrical layout and alignment measurements of equipment for checking steering and suspension systems.

Expansion of the application of vector diagrams to velocity diagrams for the slider-crank-chain mechanisms used in plant vehicles and reciprocating engines and to problems in the balancing of single cylinder and multi cylinder in-line engines.

Sketching and drawing of assemblies and component details to cover the scope of the plant technology syllabus.

## MATHEMATICS

Laws of logarithms. The idea of base. Transforming system, logs form to index form and vice versa. Change of base - log. Use of niperian log tables.

Solution of experimental equations.

Log-log graphs ( $y = ax^n$ ).

Angles greater than  $90^\circ$ .

Compound angles formulae. Graphs of compound and double angle trig functions.

Period, amplitude frequency. Phase. Compound waves.

Further quedractic equations. Solution by graphical means.

Further measurement of cross section, cone and pyramid.

Arithmetical progression.

Geometrical progression and its applications to gearing.

Arithmetic mean and standard deviation.

Histograms and distribution curves.

Elementary theory of probability.

The use of Binomial expansions for engineering approximations.

Distribution curves. Binomial (and the significance of standard deviation). Poisson.

Problems in other subjects where a mathematical solution is required.

Pappus theorems.

Differentiation of a simple expression such as  $y = \frac{n}{ax}$ ,  $y = ax^2 + c$ ;  
 $y = \sin(ax + b)$ ;  $y = \cos(ax + b)$ .

Integration as a process of summation and as the reverse of differentiation.  
General application of differentiation and integration to typical problems  
encountered in plant technology such as: work done during expansion and  
compression to the law  $PV^n = \text{constant}$ ; relation of distance, time, velocity  
and acceleration in uniformly accelerated motion, simple harmonic motion  
and in the motion of a piston in a reciprocating engine.

Graphical determination of velocity/time and acceleration/time graphs for  
cam-operated mechanisms and for the piston in a slider-crank-chain mechanism.

## ENGINEERING SCIENCE

### MECHANICS'

Impulse, impulse and momentum. Direct impact. Mechanical energy, potential  
energy, Kinetic energy. Conservation of energy. Kinetic energy of a  
rotating mass.

Radius of gyration. Centripetal and centrifugal forces, qualitative appli-  
cation to governors and clutches.

Forces on a vehicle due to acceleration and braking. Problems involved  
with weight transfer. Quantitative treatment of the relationship between  
stopping distance and braking efficiency.

Rolling resistance, gradient resistance, air resistance, tractive efforts  
and tractive resistance. Power expressed as a product of force and velocity  
or torque and angular velocity.

Power available and power required. Vibrations and oscillations.

Examples from plant applications such as spring oscillations, chassis  
vibrations and valve operation. Frequency, periodic time and amplitude.

### HEAT

Shrink fits and the necessity to make allowances for the variation of  
clearance and interference fits with changes in temperature.

Volumetric expansion and contraction of liquids. Need for venting and  
cooling hydraulic systems. Sensible and latent heat and enthalpy; vapour  
pressure of liquids.

## HEAT ENGINES

Mechanical equivalent of heat, conversion to mechanical energy and vice versa, losses involved and efficiency of conversion.  
Specific fuel consumption and thermal efficiency.

Types of test and methods of testing, dynamometers. Principles and use of high speed engines indicator. Consideration of pressure/volume and pressure/crank angles diagrams.

Effects on the form on the diagram of throttle opening, ignition setting, compression ratio, valve setting, fuel injection pump setting and super charging. Use of the planimeter. Determination of indicated mean effective pressure and indicated power from the indicator diagrams. Engine heat losses and heat balance.

## FLUIDS

Fluid and atmospheric pressure gauges, the barometer. Archimedes principle, the hydrometer. Pressure and velocity, head of a fluid, its potential and kinetic energy. The flow of a fluid through an orifice.

## HYDRAULIC AND LUBRICATION

The movement ratio, force ratio and mechanical efficiency of hydraulic jacks and presses. Hydraulic fluids in brake and hydraulic systems. Action of fluids on natural and synthetic rubber seals. Use of rolling elements to reduce friction in learning. Lubrication of ball and roller bearings. Pre-lubricated and self lubricated bearings.

## ELECTRICAL

Semi conductors. Simple explanation of the functions of the common types of diodes, transistors and zener diodes.  
Alternators. Armature and field winding arrangements in typical generators. Rectification of A. C. and D. C. by static rectifier. D. C. generators; armature and field arrangements, brush gear. Regulation of output of generators by field current control by using electro magnetic and solid state regulators.

## CONSTRUCTION PLANT TECHNICIANS' SYLLABUS PART II

### ENGINEERING SCIENCE

#### HEAT ENGINES

Consideration of I. C. engine cycles of operation, theoretical and practical; based on the combustion processes; air standard efficiency of an engine; relative efficiency. Practical ranges of air/fuel ratios for S. I. and C. I. engines. Effect of altitude on engine performance. Storage and handling of fuels.

#### MECHANICS

Gearbox reduction torque. Determination of gearbox ratios from engine/speed ratio.

Problems involving triangle and polygon of forces with reference to structural arrangement of lifting mechanisms also brake shoes and their reaction on the drum. The relationship between pedal effort and braking force for both mechanical and hydraulic operation.

Steering gear torques, direct and reversed efficiencies of operation.

Speed, velocity and displacement, relative velocity, angular velocity in revolutions per minute and radians per second. Velocity vectors. The effect of centrifugal force on the stability of machines and vehicles when on banked and unbanked tracks.

Static and dynamic balancing of rotating and reciprocating part. Principle of harmonic balancers and their action.

#### MATERIALS

Material behaviour when subjected to various loads in tension compression and shear forces. The relationship between load, stress, and strain and their effect on plant vehicle members.

Module of elasticity and rigidity. The elastic limit, modulus of elasticity and ultimate strength when testing materials to destruction.

The influence of heat treatment on the properties of steels, light alloys and copper alloys. Hardness test.

The characteristics of common steels and alloy steels. A brief outline of the physical properties and uses of nickel and nickel chrome alloy constructional steels, corrosion resistance steels, non ferrous alloys, magnesium base alloys, alloy and high duty cast irons, cast and wrought aluminum alloys, bearing metals. Hard surfacing materials and their uses. Fatigue in metals, factors affecting fatigue failure, recognition of failures due to fatigue.

Strength of materials. Bending; moments and shear force distribution in simply supported and cantilever beams, with relation to plant structure. The resistance to bending of beams of rectangular, circular (solid and hollow) channel and I section, relate to plant structure. Influence of cross section and length on resistance to twist. Critical speed of rotating shafts. Laminated or leaf spring design. Helical spring design. Use of torsional resilience in springs and in shafts subjected to torque fluctuation. Properties and application of glass reinforced Polyester Resin for plant construction.

## CONSTRUCTION PLANT TECHNICIANS' SYLLABUS PART II

### SCIENCE PRACTICAL

Experiments or demonstrations to show the differential of expansion of related components, such as piston rings and bore, gudgeon pin in piston or connecting rod, bearing and shaft.

The fitting of components by thermal methods.

Experiments to show the flow of fluids through various types of orifices and nozzles. The venturi meter.

The morse test as a means of estimating indicator power and mechanical efficiency. Simple heat balance experiments.

Simple boiler tests to show the relationship between the pressure on a liquid and its boiling temperature.

Centrifugal force machine experiments. Demonstration to show the application of centrifugal force in a spring loaded governor.

Use of a dummy rig to measure the turning moments on the crank shaft for a given load on the piston.

Simple fly wheel experiments to show the energy equation.

Experiments using hydraulic jacks.

Measurement of acceleration forces; fletcher's trolley or similar experiments.

Experiments on pendulums and low rate helical and cantilever springs.

Measurement of crank connecting rod and piston displacement to show variations in movement.

Engine testing by high speed indicator.



CONSTRUCTION PLANT TECHNICIANS' SYLLABUS PART II

SCIENCE PRACTICAL

Direct measurement of air consumption of S. I. and C. I. engines to determine volumetric efficiency.

The volumetric efficiency as determined from the analysis of the brake mean effective pressure consumption loop or torque consumption loop.

Simple exhaust gas analysis using the Orsat apparatus and the electrical combustion analyzer.

Measurement of brake pedal force and its relation to brake efficiency.

Testing of steering boxes for direct mechanical efficiency by applying a known torque at the steering wheel and measuring the reaction at the drop arm. Comparison with the reversed efficiency when the known torque is applied to the drop arm.

Static and dynamic balancing of rotating and reciprocating masses.

Testing of materials for tension, compression and shear.

Commercial hardness test. Simple heat treatment of carbon steels.

Simple bending of rectangular and circular sections (solid and hollow).

Testing in torsion of rectangular and circular shafts (solid and hollow section).

Experiments to show stability of cranes.

## CONSTRUCTION PLANT TECHNICIANS' SYLLABUS PART III

### WORKSHOP ORGANIZATION

Layout and maintenance of premises.  
Specialist equipment in the workshop.  
Service Tools.  
Costing, charging and invoicing.  
Work study and operation planning as applied to standard repair schedules and standard time.  
Job control systems.  
Wage structures.  
Bonus and incentive schemes.  
Preventative and planned maintenance.  
Repair schedules and servicing plans, service record, pre-delivery and after sales servicing, manufacturers service bulletines and technical instructions, overhaul manuals.  
Inservice inspection methods and techniques.  
Warranty procedures and handling of claims.  
Repair workshop organization.  
Plant workshop damage and defect organization.  
Plant recovery equipment.  
British standards relating to construction plant equipment, design and operation.  
Qualifications of staff at all levels.  
Obligations to manufacturer.  
Insurance policies, excess and no claim bonuses.

### PARTS DEPARTMENT AND SALES

Siting of stores and its layout.  
Basic stores documentation and records.  
Goods received notes, damage and shortage reports, return to store notes, copy orders, bin cards, stock record cards.  
Sales promotion.  
Basic consideration of salesmanship.  
Personal qualities of a salesman.  
Sequence of a sale.  
Importance of product knowledge.  
Overhead costs, operating costs and profitability.

## CONSTRUCTION PLANT TECHNICIANS' SYLLABUS PART III

### PRINCIPLES OF MANAGEMENT

### PRINCIPLES OF SUPERVISION

#### INTRODUCTION

The role of the supervisor in the construction plant industry.  
Levels of responsibility; significance and scope.  
Planning and controlling work.  
Personal aspects, safety health and welfare.

#### INDUSTRIAL RELATIONS

The human factor - problems of change.  
Worker and worker. Worker and management. Worker and machine.  
Building and maintaining a team spirit.  
Motivation, discipline, grievences and interviews.  
Existing mechanisms for consultation, negotiations and conciliation.  
The role and function of the Trade Union.  
Industrial Relation Act.  
The role and function of training boards.  
Labour utilization, instruction and training.

#### COMMUNICATION

Channels of communication; verbal and written.  
Reports, memos and letters.

#### ADMINISTRATION

Authority and responsibility, delegation by communication and involvement, co-ordination and control of activities.  
Man power budgeting, promotion and succession.  
Recruitment, selection and training of personnel (for workshop and office).  
The employment of mobile and site based mechanics.  
Basic work study techniques and data processing.  
Critical path analysis, utilization of equipment.  
Plant control. The role of the computer.  
Simple treatment of input, processing and output of a computer installation.  
Application of computer techniques to maintenance of plant records and plant management.  
Records of machines, depreciation, written down value and investment grant.  
Estimated service life.  
Profit, cost and utilization.  
Operating costs and overheads. Higher costs. Hourly cost, variable cost.  
Cost of servicing and repairs.

## CONSTRUCTION PLANT TECHNICIANS' SYLLABUS PART III

### COMMERCIAL PRACTICE

#### THE OFFICE

Its place as an integral part of a business organization.  
Brief outline of the functions and relationships of the main divisions of the office; purchasing, sales, cashier, accounts, personnel and administration.

#### ESSENTIAL OFFICE SKILLS

Control of correspondence and filing, storage of information and retrieval.  
Main types of filing; indexing and maintaining records.  
Telephone service and the proper use of the telephone.  
Calculations, involving; price, percentage applied to buying and selling; turnover, cost, wages, salaries, interest, discount and commission.  
Desk calculating machines and Ready Reckoners.

#### COMMERCIAL TRANSACTIONS AND FINANCIAL ASPECTS

Wholesale and retail price.  
Function of wholesale and retailer.  
Trade discounts.  
Cash and credit sales.  
Documents involved - quotation, order, invoice, credit note, debit note, statement.  
Credit facilities and installment trading.  
Books required for entry of credit purchase, sales, cash recording and petty cash.  
Function of money; coin, note, legal tender, order, bearer, crossed and un-crossed cheques.  
Bankers Drafts and credit transfers.  
Bills of exchange, promissory notes.  
Postal and money orders.  
The types of Banks and the services rendered by them.  
Current accounts, deposit accounts, loans, overdrafts.  
Bankers orders, travellers cheques, credit cards.  
P. A. Y. E. National Insurance, staff records.  
The principle advantages and scope of Insurance, e.g. fire, motor, burglary, employer liability and guarantee.

CONSTRUCTION PLANT TECHNICIANS' SYLLABUS PART III

LAW AND LEGISLATION OF PLANT AND TRANSPORT

Regulations affecting the sale of goods under common law.  
Contract, agency. Sale of goods act.

Factories act; offices, shops and railway premises set.

Condition of employment. Redundancy payments set.  
The law of lion.

Disposal of uncollected goods.

Transport set regulations as applicable.

Construction and use regulations.

Road traffic acts.

Light regulations.

Police Tests.

Operation and testing of vehicles.

Trade plate regulations.

Regulations relating to the purchase, road transportation storage and  
sale of petrol, oil, paint and other dangerous substances.



Ⅱ-6 工学部 建築土木学科 かんがい





**SYLLABUS**  
**AND**  
**REGULATIONS**  
**FOR**  
**TECHNICIAN CERTIFICATE**  
**IN**  
**IRRIGATION ENGINEERING**

## TECHNICIAN CERTIFICATE (PART III)

### IN

### IRRIGATION ENGINEERING

#### 1. INTRODUCTION:

THE JOMO KENYATTA COLLEGE OF AGRICULTURE AND TECHNOLOGY OFFERS A 4 - YEAR COURSE IN IRRIGATION ENGINEERING LEADING TO TECHNICIAN CERTIFICATE PART III IN IRRIGATION ENGINEERING. THE COURSE IS INTENDED TO PREPARE THE STUDENTS FOR FUTURE POSITIONS AT SUPERVISORY AND TECHNICIAN LEVELS IN IRRIGATION ENGINEERING.

#### 2. DURATION OF THE COURSE:

The period of study is 4 years full-time and consists of the following stages:

- PART I Stage - consisting of 3 terms
- PART II Stage - consisting of 4 terms
- PART III Stage - consisting of 1 term of inservice training and 4 terms of college study.

Each term consists of approximately 14 working weeks.

#### 3. COURSES OF STUDY:

The subjects and the allocation of time for each subject are as set out below:

SUBJECTS OF STUDY	TEACHING HOURS PER WEEK			TOTAL TEACHING HOURS
	PART I Stage	PART II Stage	PART III Stage	
1. APPLIED MATHEMATICS	4	2	-	280
2. ENGINEERING DRAWING	4	-	2	280
3. MECHANICS AND STRUCTURES	4	4	-	392
4. MATERIALS AND CONCRETE TECHNOLOGY	2	4	-	308
5. CONSTRUCTION SURVEYING	4	4	-	392
6. ENGINEERING SERVICES	2	-	2	196
7. FOUNDATION ENGINEERING	-	2	4	336
8. HYDRAULICS AND HYDRAULIC MACHINERY	-	2	2	224
9. ENGINEERING HYDROLOGY	-	2	4	336
10. IRRIGATION ENGINEERING	-	2	4	336
11. SITE ORGANISATION AND ADMINISTRATION	-	-	4	224
12. MEASUREMENTS AND SPECIFICATIONS	-	-	6	336
13. ENGLISH AND RELATED STUDIES	2	-	-	84
14. WORKSHOPS THEORY AND PRACTICE				
(i) MASONRY	4	-	-	168
(ii) CARPENTRY	4	-	-	168
(iii) MECHANICAL	-	4	-	224
(iv) ELECTRICAL	-	4	-	224
TOTAL HOURS PER WEEK	30	30	28	

4. EXAMINATION SCHEME:

The examination scheme, the subject, duration and maximum marks are as tabulated below:

S. NO.	NAME OF PAPER	DURATION IN HOURS	MAXIMUM MARKS
<u>PART I STAGE: INTERNAL EXAMINATIONS</u>			
1.	APPLIED MATHEMATICS	3	100
2.	ENGINEERING DRAWING	3	100
3.	MECHANICS AND STRUCTURES	3	100
4.	MATERIALS AND CONCRETE TECHNOLOGY	3	100
5.	CONSTRUCTION SURVEYING	3	100
6.	ENGINEERING SERVICES	3	100
7.	WORKSHOPS: MASONRY AND CARPENTRY THEORY	3	100
<u>PART II STAGE: EXTERNAL EXAMINATIONS</u>			
1.	MATHEMATICS	3	100
2.	MECHANICS AND STRUCTURES	3	100
3.	MATERIALS AND CONCRETE TECHNOLOGY	3	100
4.	CONSTRUCTION SURVEYING	3	100
5.	HYDRAULICS AND HYDRAULIC MACHINERY	3	100
6.	ENGINEERING HYDROLOGY	3	100
7.	WORKSHOPS: MECHANICAL AND ELECTRICAL THEORY	3	100
8.	SURVEYING: PRACTICALS	4	100
9.	MECHANICAL WORKSHOP: PRACTICAL	3	50
10.	ELECTRICAL WORKSHOP: PRACTICAL	3	50

NOTE: (1) Papers (4) and (8) are combined and percentage obtained to compute the grade on that subject.

(2) Papers (7), (9) and (10) are combined and percentage obtained to compute the grade on that subject.

S. NO.	NAME OF PAPER	DURATION IN HOURS	MAXIMUM MARKS
<b><u>PART III STAGE: EXTERNAL EXAMINATIONS</u></b>			
1.	FOUNDATION ENGINEERING	3	100
2.	ENGINEERING SERVICES	3	100
3.	HYDRAULICS, HYDRAULIC MACHINERY AND ENGINEERING HYDROLOGY	3	100
4.	IRRIGATION ENGINEERING - THEORY	3	100
5.	IRRIGATION ENGINEERING - DESIGN AND DRAWING	4	100
6.	SITE ORGANISATION AND ADMINISTRATION	3	100
7.	MEASUREMENTS AND SPECIFICATION	4	100

For examinations at PART I and PART II Stages, the papers are set on the subject matter covered in their respective stages only. But for examinations at PART III Stage, the papers are set on the complete prescribed syllabus in their respective subjects.

## 1. APPLIED MATHEMATICS

### PART I Stage (about 168 hours)

Indices and logarithms - law of indices equations involving logarithms, change of base. Principle of slide rule.  
Common fractions, simplification, addition, multiplication, divisions, etc.  
Theorem of pythagoras - use of square and square root tables, and problems involving use of Pythagoras.

Perimeter and areas of circle rectangle, triangle; trapezium parallogram, quadrilateral, irregular polygon and regular polygon. Areas of figures with irregular boundaries by simpson's rule. Volume and surface area of any right solid prism, rectangular solids and sphere.

Circular measure (radian measure) of an angle. Use of tables for changing degrees to radians and vice versa. Length of arc and area of a sector of a circle Area of a segment of a circle. Problems involving calculation of areas and perimeter of a sector and segment.

Simple algebraic expressions - solutions, factorisation and rationalisation. Binomial theorem.

Irregular areas and volumes - estimation by squared paper, by planimeter, trapezoidal rule, mid-ordinate rule, Simpson's rule and prismoidal rule. Theorem of Pappus - for surface area and volume Centroid of composte area.

Progressions - arithmetical progressions and simple interest, geometrical progressions and compound interest.

Basic trigonometry - basic trigonometrical ratios and relationships between them. Deduction of trigonometrical ratios one from another. Angles of elevation and depression solution of triangles etc. Line of greatest slope. Hipped roof with rectangular plan.

### PART II Stage (about 112 hours)

Calculus - differentiation of constants, a sum of terms and of more examples requiring a substitution standard forms of differentiation. Application of differentiation - Velocity and acceleration, equations of motion, maxima and minima and radius of curvature. Integration - standard forms. Application of integration to simple area, volume, length of arc, centroid of area, centroid of solids and moment of inertia.

Graphs - plotting, straight line of graph. Interpolation and extrapolation. Determination of laws. Reduction to straight line forms. Line charts with linear and non-linear scales.

Statistics - recording of information, bar chart, pie chart, horizontal bar chart. Graphs. Frequency distribution table. The histogram, frequency polygon and distribution curve. Types of average - mean, median and mode.

Cumulative frequency curve. Standard deviation, tabulation of data. Grouped distribution and normal distribution curve. Importance of the standard deviation.

Introduction to numerical methods of computation.

## 2. ENGINEERING DRAWING

### PART I Stage (about 168 hours)

Equipment - the mechanics of engineering drawing, personal equipment, drawing office equipment and first steps in drawing.

Projections - orthographic projection, third angle projection combined projection, applications. Sections, auxiliary views, pictorial drawings and interpretations.

Conventions and presentation - size of drawing, layout scales, types of line - sectioning, dimensions and levels. Slopes, falls, batters and gradients. Lettering.

Points, lines - surfaces and shadows - lines, descriptive geometry, developments, intersections, shadows, etc.

Conics - construction of a conic from a given cone, graphical construction of ellipse, parabola and hyperbola.

Measured perspective - single point and two point perspective construction - realistic completion.

### PART III Stage (about 112 hours)

Drawing in practice - site surveys and investigation tender drawings, contract drawings, working drawings, completion record or 'as-built' drawings - illustrative cases. Application to detailing reinforced concrete steelwork etc. Surveying applications.

Drawing office and reproduction of drawings - plane references, storage, reproducing drawings, microfilming and slides.

## 3. MECHANICS AND STRUCTURES

### PART I Stage (about 168 hours)

SI unit - base and derived units. Force - balanced and unbalanced forces. Equilibrium. Action and reaction concurrent and coplanar forces.

Composition and resolution of forces parallelogram of forces, Resultant and equilibrium. Triangle of forces. Polygon of forces.

Non - concurrent coplanar forces parallel forces. Moments, torque and couples. Reactions at the supports of loaded beam. Resolution of forces by graphical and analytical methods.

Centre of gravity and centroid for common figures types and conditions of equilibrium A.

Linear displacement - speed and velocity, displacement and time graphs, velocity and time graphs, acceleration and time graphs. Area under graph. Equations of motion. Acceleration due to gravity Newtons laws. Work, energy and Power - units, conservation of energy. Momentum and its conservation. Impulse of a force.

Angular displacement, angular velocity and angular acceleration. Moment of inertia of a flywheel, by accelerating under a force, and by torsional oscillations.

Friction - types and coefficients and sliding effects.

Loads - axial and non-axial, general effects, ground pressures and safe bearing capacity. Brief introduction to static earth and water pressures. Stability calculations.

Strength of materials - stress, strain and E, ultimate tensile stress, safe working stress and factor of safety temporary stress and poisson's ratio. Modular ratio - Principles in composite materials.

Section properties and theory of bending.

Shear force and bending moment for simply - supported overhang and cantilever beams. Analytical and graphical methods. Shear distribution.

## PART II Stage (about 224 hours)

Structural design procedure - dead and imposed loading for roofs and floors columns and foundations; reduction factors for imposed floor loads on columns and beams; alternative loadings for beams and slabs. Wind and earthquake forces. Working stresses, factor of safety and causes of failure.

Design of structural elements:

Timber - working stresses, stress grading, nett sizes, direction of grain, allowance for defects. Design of timber sections in bending, shear and deflection standard truss forms and stress calculations Joints in trusses and timber framing - nails, bolts, connectors, glues and adhesives Design of horizontal and vertical shuttering.

Reinforced concrete - elementary principles, elastic and load factor theory shear and bond considerations concrete mixes and working stresses. Design of rectangular beams and slabs of balanced section, simply supported and continuous. Tee and 'L' beam design. Design of columns - Short and long. Simple square and rectangular footing for axially loaded isolated columns. Design of retaining walls gravity dams, piles tanks. Designs related to relevant code of Practice CP's 114/115 and others.

Prestressed concrete - simple calculation for a prestressed beam.

Structural steelwork - standard sections and properties working stresses. Design of beams for bending, shear, buckling, lateral stability, bearing and deflection. Cased and uncased sections. Design of columns and tension members. Design of rivetted, welded and bolted joints. Design of steel tanks. Designs related to relevant standards B.S. 449 and others.

Load bearing walls - Types of wall materials, design considerations, effective height, restraint, thickness, slenderness ratio, safe working loads for solid and cavity walls, with and without opening. Eccentricity of loading.

#### 4. MATERIALS AND CONCRETE TECHNOLOGY

##### PART I Stage (about 84 hours)

Building materials - general introduction, origin and classification of various materials. Explanation of materials and components.

Building stone - igneous, sedimentary, meta-morphic rocks properties and tests. Suitability and selection for various purposes.

Bricks - various types and manufacturing processes, properties and standard tests. Hollow clay bricks clay roofing tiles, their properties, method of manufacture and standard tests.

Plasters and mortars - general requirements of plaster gypsum plaster and gypsum plasterboards, manufacture, type and uses Tests.

Lime in building - manufactures, types and uses. Tests for limes.

Plastics and rubbers - types and uses. Properties and selection methods.

Paints - composition and uses of different types. Standard test.

Ferrous metals - types, common alloys, heat treatment and identification methods. Steel, properties and standard tests. Causes of corrosion and methods of protection. Outline of manufacturing process.

Non-ferrous metals - types and properties, selection criteria for various uses.

##### PART II Stage (about 224 hours)

Timber - structure, conversion, curing, seasoning preservation methods and properties. Defects and timber diseases, methods of protection.

Stress grading and standard tests. Timber products - solid and laminated, manufacture, properties uses and selection criteria.

Bituminous products - properties and standard tests.

Concrete technology - brief survey of the use of plain concrete, reinforced concrete, precast concrete, prestressed concrete etc.

Cement - types, characteristics, properties and their particular use.

Packing transportation and storage methods. Locally available cements.

Precautions on use,



Aggregates - types of available aggregates fine and coarse. Properties and selection of aggregates for a particular use. Bulking of sand and adjustments. Usual method for ordering and the supply of aggregates, methods of storing for large and small projects, site tests for cleanliness, grading and other properties. Laboratory tests.

Water - suitability and tests.

Reinforcements - stacking, bending, cleaning and fixing reinforcements. for columns, slabs, beams etc. Site layout for prefabrication.

Formwork - Preparation, treatment and removal concrete mixes - specification for concrete mixes volume weight and strength, advantages and disadvantages of each. Water-cement ratio, workability. Essential properties. Concrete mixing plant types, selection for particular use, and plant layout. Admixtures - uses and effects. Standard laboratory tests. Quality control techniques.

Transporting concrete basic considerations, types of plant used, and their particular use.

Placing and compacting concrete - for various site works, tools and equipments used for placing and compaction.

Protecting and curving of concrete - reasons for and methods of curing and protection curving methods. Concreting in adverse conditions.

Construction joints - basic considerations and forming joints. Different methods.

Finishing concrete - types and methods.

Reinforced concrete - necessity for reinforcements, types and quality of reinforcement - Bar bending equipments and methods.

Precast products - unit production, storage, handling and fixing. Brief survey of typical precast products and their manufacture.

Prestressed concrete - object of prestressing, materials used, storing on site, basic methods of post - tensioning and pre-tensioning. Types of equipment. Handling cutting and drilling of pre-stressed concrete units. Types of prestressed concrete units in application.

Spray application of concrete. Repairs to concrete.

## 5. CONSTRUCTION SURVEYING

### PART I Stage (about 168 hours)

Basic principles of surveying - units of measurement and governing principles. Elementary mathematics.

Plan scales - methods of showing scale, conversion of scales to representative fractions, conversion of areas by representative fractions.

Ordnance Survey maps and plans - scales of OS maps size of maps and types of maps, depiction of surface relief and conventional signs.

Linear surveying - linear measuring equipments, slope conversion, chain and tape errors in measurement, procedure in linear surveying, obstacles to measuring and plotting the survey.

Levelling - levelling instruments, levelling staff, types.  
Telescope - law of reflection, refraction, types of lenses.  
Taking a reading, booking the readings, reducing by rise and fall and H. J. Methods, inverted staff readings errors in levelling, permanent adjustment, curvature and refraction. Reciprocal levelling.

Vertical sections - longitudinal sections, cross sections, levelling and plotting.

Contouring - contour line, methods of contouring and use of contour maps.  
Bearings - magnetic bearings, true bearings, magnetic declination, assumed bearings, FB and BB, reduced bearings and conversions.  
Prismatic and surveyor's compass, traverse surveying accuracy and limitations of compass surveying, plotting and adjustment, corrections for local attraction, errors and adjustments.

Rectangular co-ordinates - basic principle, calculation of open compass traverse, plotting rectangular co-ordinates, and calculation of a closed traverse.

Areas and volumes - areas from field notes, measuring areas from plans, planimeter. Volumes - cuttings and embankments, Simpson's rule, Prismoidal rule, volumes of large scale earthworks, volumes from spot levels and contours. Earth quantities and mass haul diagrams.

## PART II Stage (about 224 hours)

Setting out - small buildings, large buildings and other horizontal controls setting out for excavation, for drains and other vertical controls.

Theodolites - vernier and modern types, setting up measuring horizontal and vertical angles and care. Theodolite traversing - types, orientation of traverse surveys, fieldwork, computations, plotting and adjustments.

Tacheometry - Tangential, stadia tacheometry, subtense measurements, and applications.

Curve ranging - curve geometry, curve elements, designation of curves, problems in curve location and setting out horizontal and vertical curves.

Introduction to photogrammetry, aerial and hydrographic surveying methods.

## 6. ENGINEERING SERVICES

### PART I Stage (about 84 hours)

Domestic cold water supply - water supply, sources, demand, cold-water system, taps and valves, materials for pipes Domestic Hot-water supply-systems, electric and gas water heaters.

Drainage below ground - principles, means of access sewage pumping - pumps, drainage pipe materials, drainlaying, use of soakaways, garage drainage drain testing and inspection, sub-soil drainage and grease traps.

Soil and waste systems above ground - principles one pipe system, two-pipe system and single stack system, loss of water seal, re-sealing and anti-syphon traps, materials used and testing.

Sanitary appliances - types, sanitary provisions for factories, hotels, office buildings - schools etc.

Refuse disposal - storage, refuse chutes, Garchey system, sink grinders, pneumatic and transport of refuse.

### PART III Stage (about 112 hours)

Rainwater disposal - methods and calculations involved outline of large scale conventional water and sewage treatment works - unit description. Small scale sewage treatment works - principles and design of various units.

Local Government by-laws on refuse disposal, water supply, ventilation, drainage, sanitary conveniences sewers, septic and conservancy tanks of buildings.

Traffic engineering - traffic flow, road types and capacities road layouts - road design, road junctions, traffic surveys, traffic control, parking and landscapes. General treatment of above topics with emphasis to construction methods. Out line of housing development, town and country planning techniques.

## 7. FOUNDATION ENGINEERING

### PART II Stage (about 112 hours)

Geology: Minerology  
Petrology  
Weathering and erosion  
Structural geology  
Tunnelling and quarrying  
Site investigation  
Geology of dams - site investigation, leakage, grouting  
settlement, slips and subsidences mining of dams,  
earthquakes and failure of dams.  
Reservoir and catchment geology. Erosion and silting  
phenomena. Use of Geological maps.

Soils - nature of soils, physical and chemical degradation soil horizon, residual soils, transported soils, etc.

Physical properties of soils - structure, void ratio and porosity, water content, specific gravity, density and relative density.  
Cohesion, plasticity and consistency.

Field investigations - surface and sub-surface exploration report of field investigations and field tests.

Simple laboratory tests - water content, specific gravity, void ratio and porosity, mechanical analysis and consistency limits.

### PART III Stage (about 224 hours)

Classification and identification of soils - classification systems and identification techniques.

Permeability, capillarity and seepage - Darcy's law, laboratory, tests for permeability and Field test. Capillary effects, seepage pressures, flow nets and piping.

Consolidation - theory, lab tests for consolidation characteristics settlements.

Shear strength - general considerations, unconfined compression tests, direct shear test, triaxial test and shearing characteristics of various soils.

Stability of slopes - methods of analysis, and surcharge conditions.

Retaining structures - active and passive pressures, wall friction, wedge action, Rankine theory, slopes with surcharge, design of retaining walls and sheet pile walls.

Bearing capacity - approach to bearing capacity, distribution of stresses, field load tests and design considerations.

Soil compaction - principles, CBR test, field compaction and field control measures.

Soil stabilization - soil - cement mixtures, soil - asphalt mixtures, intrusion grouting, vibrofloatation, well pointing, electro-osmosis, chemical admixtures, grouting - equipments, grout volumes, grouting pressures, properties of stabilizing soils grouting patterns and typical applications.

Design of foundations - soil considerations, soil explorations and soil tests, bearing pressure, inter-dependence of ground, substructure and superstructure, types of foundation exclusion of ground moisture design in relation to construction procedure and protection of the foundation soil.

Shallow foundations - design considerations, selection of types, pad, strip and raft foundations, safety precautions and support of excavations.

Deep and subaqueous foundation - types, choice of type allowable bearing pressure and settlement calculations.

Cofferdams and caissons - design considerations, determination of pressures and safety precautions.

Geotechnical processes for dewatering - preliminary site investigation, exclusion of water from excavations, Methods of dewatering excavations - gravity drainage, pumping from inside the excavation and from sumps or well points outside the excavation. Special methods for excluding water from excavations - use of compressed air, freezing, diaphragm walls and injection methods. Methods of improving the physical properties of the ground - shallow and deep compaction and use of sand drains, and safety precautions.

Pile foundations - investigations of ground, design considerations, choice of type, piles in groups, pile caps and factor of safety. Types of piles - timber, precast, reinforced concrete, driven, cast - in-place, bored cast-in-place, steel and screw piles. Bearing capacity and loading tests on piles.

Tidework and under-water concreting - construction, working methods and conditions.

Excavation, demolition shoring and underpinning - preliminary investigations, protective supervision and procedure.

Durability of timber, metal and concrete structures - protective measures.

## 8. HYDRAULICS AND HYDRAULIC MACHINERY

### PART II Stage (about 112 hours)

Physical properties of water - mass, force, density, specific weight bulk modulus surface tension, adhesion, capillarity and viscosity. Methods of measurement and importance to hydraulics. Ideal fluid. Atmospheric pressure.

Laws of fluid mechanics - conservation of mass, conservation of momentum, conservation of energy, the concepts of energy transfer, etc.

Water pressure - hydrostatic pressure and force, vertical and slanted planes, curved planes and buoyancy.

Flow in pipes - empirical, scientific, and conveyance methods, local losses, design of piping systems and water hammer. Detailed analysis of pipe networks. Deterioration of pipes.

Open channel flow - critical flow condition, non-critical flow condition, natural conditions of steady flow, concept of normal flow, design of stable channels, and best hydraulic section. Backwater and channel delivery computations. Scouring and silting phenomena.

Flow measurements - classification, pipe flow measurements, flow through small and large orifices, flow through notches and weirs and river flow measurements.

### PART III Stage (about 112 hours)

Flow through hydraulic structures - sluiceways gates, spillways, weirs, culverts, etc. Energy dissipators. General design considerations. Inflow and outflow relationships at a reservoir.

Model analysis - physical significance of modelling laws - laws of similarity. Types of model investigation and methods of analysis of common types of river and channel models. Measuring instruments and techniques. Dimensional approach to experimental analysis.

Centrifugal pumps - Basic principles, basic classification - construction of pumps, installation, operation, troubleshooting, performance and selection, maintenance and testing.

Rotary pumps - principles of operation, construction, installation, troubleshooting - performance and selection.

Reciprocating pumps - principles of operation, construction, performance and selection.

Special service pumps - chemical and process pumps, pumps for handling of sewage and other special service pumps - performance and selection.

Hydraulic accumulators - basic construction and operation, types of accumulators, air and vacuum chambers.

Power transmission - hydraulic drives, types, principles of operation and construction.

Hydraulic power tools - hydraulic circuits - hydraulically controlled circuits, and operation of hydraulic circuits.

Hydraulic cylinders - rotating and non-rotating types control valves - pressure controls, flow controls, directional controls and speed flow control operators.

Hydraulic fluids - petroleum-base fluids, synthetic - base fluids, quality requirements, maintenance, change of fluids in a hydraulic system, selection of a hydraulic fluid and hydraulic filters.

Fluid lines and fittings - rigid pipes, semirigid tubing, flexible piping, manifolds.

Turbines - types, performance characteristics selection, installation and maintenance. Testing of common types of turbines outline of hydro-electric schemes.

## 9. ENGINEERING HYDROLOGY

### PART II Stage (about 112 hours)

General: Scope of hydrometeorology, functions of hydrometeorological services and basic data. Organization of hydrological and meteorological services, outline on recommended practices and procedures in hydro-meteorological and recommended units for various elements.

#### Instruments and methods of observation:

Precipitation - gauge location, types of gauges, measuring devices, errors and accuracy of readings. Rainfall intensity recorders.

Evaporation - pan evaporation description of pans, auxiliary equipments, layout of evaporation stations and observational procedure. Soil evaporimeters and lysimeters - description of evaporimeters auxiliary equipment, location and selection of plots and catchment evapotranspiration.

Water - budget method - lake or reservoir evaporation inflow and outflow, net seepage and bank storage, change in reservoir storage.

Energy budget method - solar radiation, air temperature, water surface temperature, humidity or vapour pressure of the air, stored thermal energy, recording devices, aero-dynamic approach.

Water temperature - purpose of measurement, temperature condition of lakes and streams, instruments used for point-to-point measurements and continuous measurements, observational procedure.

Soil moisture - sample collection, samplers, description accuracy and use.

#### Instruments and methods of observation:

Measurement of stream stage and discharge - purpose of stream gauging stations, selection of site, stage measurements, and discharge measurement methods. Instruments and equipment - manual and recording gauges for measurement of stage, meters for measurement of velocity and equipments for measurement of cross-section. Measurement of width, depth and velocity using current meter method. Computation of discharge and corresponding stage. Measurement of discharge by float method and dilution method - general requirements and procedure. Observational programme - measurement of stage and discharge.

Computation of runoff - empirical and direct methods, computation of average gauge height and average discharge.

Measurement of discharge by indirect methods - slope area measurements, measurement of flow through culverts, width contractions and over dams and highway embankments.

Measurement of sediment discharge - selection of site, sampling instruments, measurement procedure and determination of sediment concentration.  
Computation of suspended - sediment and bed-sediment discharge. Methods of observation, time and frequency of observations.

#### Design of networks:

Hydro meteorological data to be considered in determining the density of the network - Precipitation, stage and discharge of rivers and stage of lakes, evaporation and evapotranspiration, sediment transport and deposition, stream flow, minimum and optimum network. Integration of bench-mark stations and of representative catchment basins in the network-representative catchments.

#### Collection, processing and publication of data:

Collection, reporting procedure, frequency and time of observation, report forms and data abstraction, instruction to observers, inspection of stations, preliminary checking of data, relationships between climatic and hydrometric data, storage and cataloguing, regular processing procedures general and statistical methods maps of factors in the hydrological balance etc. on precipitation, streamflow, evaporation, soil moisture - publication, purpose contents and format.

### PART III Stage (about 224 hours)

#### Hydrological analysis:

Methods of analysis used in hydrometeorology. Interpretation of precipitation data - spatial distribution, iso-hyetal arithmetic, polygon, percent normal methods. Storm rainfall studies and rainfall frequencies. Adjustment of data and interpolation of missing data. Interpretation of streamflow data - runoff curves, time distribution of runoff and relation to seasonal precipitation, hydrograph analysis and unit hydrograph, monthly, seasonal and annual runoff. Streamflow routing - low flow analysis, flow duration curves, low-flow frequencies.

Statistical analysis of droughts. Flood frequencies - station analysis, peak flow, flood volume characteristics adjustment of data and long period trends.

Evaporation and evapotranspiration - water budget method, energy budget method, solar radiation, aerodynamic method, combination of aerodynamic and energy balance equations - potential and actual evapotranspiration.

#### Hydrological forecasting:

Types classification and forms of hydrological forecasting and warning - data requirements. Forecast methods - long-terms runoff forecasts, long-term forecasts of seasonal peak flow and stage, seasonal flow forecasts, annual flow forecasts, short-term runoff forecasts, forecast of lake levels, hydrological forecasting services evaluation of methods and verification of hydrological forecasts.



### Application to water management:

Descriptive treatment of water supply versus water demand, preliminary investigation of water projects, multi-purpose projects, estimation of available surface water supplies, estimation of water demand and losses, estimation of required reservoir storage capacity, estimation of design floods, design of flood control works, design of urban and small watershed drainage works.

### Ground water:

Occurance of ground water, fundamentals of groundwater hydraulics, practical groundwater flow problems, yield of wells, determination of yield. Measurements of groundwater levels in observation wells - instruments and methods.

### Water resources applied to Kenya:

Meteorology, climate, water resources drainage and relief of Kenya  
Fundamental economics of water resources development. The water  
The water ordinance-Law of Kenya.

## 10. IRRIGATION ENGINEERING

### PART II Stage (about 112 hours)

Irrigation - trends, impact on regional economic growth, efficiency of water distribution and use on the land. Drainage aspects, integrated use of surface and groundwater resources. Soil and water conservation.

Farming systems, problems of soil fertility etc. Farm management - planning budgeting etc.

Planning and designing of a perennial irrigation scheme alignment of canals, waterlevels in canals, design of canals, layout etc. Duty of water and other relevant aspects.

Farmstead and range structures - requirement, space and other considerations  
Assembly techniques.

Land levelling and surface irrigation structures and principles and practices of over head irrigation systems - site selection, design, layout operation and maintenance.

### PART III Stage (about 224 hours)

Site selection, design principles, methods of construction, layout, operation and maintenance aspects of various irrigation structures e.g. Farm structures, including sprinkler systems

Intake structures  
Canal structures  
Drainage structures  
Storage structures, crest gates etc.  
Diversion structures  
Distribution structures, modules etc.  
Detailed drawings of the above.

## 11. SITE ORGANISATION AND ADMINISTRATION

### PART III Stage (about 224 hours)

Safety, Health and welfare - Regulations and safe working conditions on site including access, excavations and scaffolding, statutory registers and diaries. Statutory inspections. Safe working conditions for mechanical plant, hoists, cranes, portable tools and electrical equipment maintenance and inspection.

Messing, washing, temporary toilet facilities and first aid. Regulations governing requirement for siting. Temporary housing for labour. Transport of labour. Responsibility for notices, building regulations and statutory requirements and fees. Responsibilities to third parties.

Management principles - line and staff relationship of functions within a company. Delegation of responsibility and accountability. Span of control and its effect of management structure. Pre-tender planning, personnel involved, objects and aims.

Site organisation and administration - parties concerned with a project, their function and inter-relationship. Employer and operative organisations. Preliminary site works, siting temporary buildings, storage and material compounds, access roads and hoardings. Site protection. Temporary services - water, gas, electricity, telephone, generators, drainage. Plant - mechanical plant requirements and siting, maintenance and repair. Scaffolding, types and erection. Consideration of distribution of materials and hoisting materials, preparation of schedules, forecasting material requirements. Processing, ordering, checking, storage, protection, transport, loading and handling.

Labour, assessment and forecast of requirements. Availability of labour and alternatives. Incentives, general principles of financial incentive schemes, measuring and recording, non-financial incentives. Site control, forecasting, over-all programme, short term programme, use and application of programmes and forecast targets. Cross programmes, object, use and effect. Progress records and feed-back of information.

Site records, reports to head office. Day-works. Variations. Progress reports. Time books and wage sheets. Material log. Notification to, and site inspection by authorities.

Basic study, proper selection and specific use of various mechanical plants used for: transporting, lifting, excavating, piling, road making and miscellaneous plants - Farm machinery - maintenance aspects and safety methods.

Workstudy - aim and scope, method study, motion study and analysis of working methods. Work measurement and frequency studies.

## 12. MEASUREMENT AND SPECIFICATIONS

### PART III Stage (about 336 hours)

Measurement - general rules of measurement of building and Civil Engineering works may be taken from "The standard method of measurement of Civil Engineering quantities" used in East . . . . . be placed on the importance of developing a good style with items . . . . . down neatly in logical sequence with adequate notes. Major exercise should be for structures covered under the subject "Basic design of Irrigation structures".

Specifications - detailing standards of workmanship quality of materials and tests covering the following trades and sections - Forms of contract, preliminaries, excavator, concreter, brick and bricklayer, drainlayer, pavior, roofer, carpenter and joiner, steel and metal work, plasterer, plumber, glazier, painter, specialist services (i.e. gas, electricity, lift ventilation etc.), external works, timberwork, jetties and wharves, railway trackwork etc.

## 13. ENGLISH AND RELATED STUDIES

### PART I Stage (about 84 hours)

The subject should aim to develop logical thinking and ability to communicate simply and accurately in speech, in writing. Practice imparted in writing brief descriptions, letter and reports in a prescribed number of words, to be followed by the introduction of customary technical terms and expressions used in the construction industry the techniques of technical writing and reporting. Preparation of a report on the project for group discussions; examples are: local building history and customs, economics of machinery versus hand labour, local trade union growth, time and motion studies, objective appraisal of working techniques in the construction industry.

## 14. WORKSHOPS - THEORY AND PRACTICE (i) MASONRY

### PART I Stage (about 168 hours)

Bonding dry bricks, English bond and Flemish bond, bonding concrete blocks, straight walls, quoins, junctions to various sized to blocks. Brickwork tools, masonry tools, care and maintenance of tools.

Laying bricks and blocks with mortar - positioning of mortar boards and bricks and blocks. Levelling, plumbing and working to gauge.

Preparation of mortar for brick or block work. Proportioning, mixing by hand and by machine.

Setting out for excavation, determining building line, setting up profiles, transferring datum etc.

Setting out for walls in foundation trench or slab foundation. Bonding straight lengths of walls. Bonding at angles. Bonding at junctions. Bonding at openings.

Laying DPC in felt and slates, horizontal and vertical. Fixing of door frames, opening to receive lintels. Bedding and fixing wall plates sills.

Bending and fixing steel reinforcements, placing, compacting, curing concrete beams, floors, columns and slabs.

Jointing and pointing. New and old work. Preparation joints. Finishes.

Plastering - preparation of materials for plastering cement and lime plasters. Sand preparation of walls for plastering. Levelling screeds. lining screeds. Floating and setting coats. Treatments to angles and reveal. Plastering to ceilings. Wooden laths and metal laths.

Scaffolds and scaffolding, metal tube scaffoldings wooden post scaffolding.

Safe working methods and logical sequence of construction.

Survey of tools and equipments, tool sharpening, care and maintenance. Standard requirements of workshop, layout of benches and services like, electricity, ventilation etc.

Safety regulations and first aid-factory acts and local regulations. Timber - selection, use and preparation standard types of timber joints, mortice and tenon, dowel joint, edge joint and dovetail joint. Use of nails, screws, dogs and adhesives.

Carcass work to floors and roofs. Joists to hollow floors, cutting, splicing, halving, fixing etc.

Use and types of power hand tools - safety timbering to trenches, for foundations and walls, formwork for various works such as for columns, foundations and footing retaining walls, beams and slabs etc. Method of erection, and ease of striking.

Erection of timber walls, pre-fabrication techniques etc. as applied to temporary and permanent sheds, farmhouses etc.

## WORKSHOPS THEORY AND PRACTICE (11) MECHANICAL

### PART III Stage (about 224 hours)

Use and preparation of engineering information - working from drawings or dimensional sketches. Free hand sketching, symbols, preparing working drawings, working from oral instructions, assembly and sub-assembly drawings.

Measuring instruments - micrometers, dial indicators, vernier caliper gauges etc. The correct choice of measuring instruments, slip gauges accessorial and their use. Sine bar - to set up a sine bar to a required angle, to measure the angle of a wedge-shaped workpiece or taper plug, and other applications. Optical projectors. Mechanical optical, pneumatic and electrical comparators.

Marking out - marking out a profile template, marking out a tube for machining of slot, groove or holes.

Roughing out - tools for roughing out, roughing out sheet metal and roughing out thick metal.

Surface finishes - lapping flat surfaces, paired castings, internal diameters external diameters and dimensional inspection. Graining by hand and by machine. polishing by free hand and controlled methods. Hand and gear burnishing.

Metal protection - protection of steel and aluminium alloys.

Joining of metals - tubular, pop solid and countersunk riveting.

Brazing, hard and soft soldering dip brazing and peening. Gas and arc welding. Heat treatment - annealing and case hardening tempering and normalising. Broaching - internal, and external broachings Broaching machines.

Hand tapping - instrument threads. Bushes and wire inserts screw housing-clinch nuts, hankbushes and anchor nuts. Grinding - selecting, mounting and balancing of grinding wheel, cylindrical surface and internal grinding operations. Common grinding faults and their rectification milling - types and application as milling cutters, mounting, setting and clamping milling machine operations. Milling faults and their correction.

Fitting new assemblies - dowelling, use of screws, bolting and locking methods, fasteners, cotter pins, circlips roll pins, taper pins, staking; wire, tension and compression springs and bearings use of stock and dies.

Adhesives - epoxy resin, jointing compound and liquid polymers for locking. Tube bending - hand operated tube benders compression and draw bending, sydraulic tube benders, bending springs, sand loaded bending.

Adhesives - epoxy resin, varnish, jointing compound and liquid polymers for locking.

Tube bending - hand operated tube benders compression and draw bending, hydraulic tube benders, bending springs, sand loaded bending. Cutting to length and threading metallic and non-metallic pipes.

Lubricants and daily maintenance - types of lubricants and principles of daily maintenance and correct procedures.

Workshop procedure - production control and inspection procedure, stores reference numbers, planning procedure, planning layouts etc.

WORKSHOPS THEORY AND PRACTICE (ii) Electrical

PART II Stage (about 224 hours)

Ohm's law and electric power - Nature of electricity, electrical units, calculation of resistance, ohm's law, voltage and current in series and parallel circuits, electric power.

Conductors and cables - insulators and conductors, construction of cables, resistivity, temperature coefficient terminations, outline of regulations.

Conduit, trunking and ducting - Type of conduit installing conduit, trunking systems ducting, catenary wiring-outline of regulations.

Distribution and control - regulations governing supply - layout of domestic and industrial installations - temporary installations.

Testing and Earthing - verification of polarity - Earth insulation resistance, earth tests, earth electrodes - outline of regulations.

Protection - electromagnetism, circuit breakers, tubes, thermal trip.

Electric heating - electrical and mechanical units, efficiency water heaters, space heating, electric cookers, tariffs.

Bells and indicating systems - types of bells, indicators the relay, telephone etc.

Batteries - leclanche cell, internal resistance, lead, acid cell, alkaline cell, methods of charging - outline of regulations.

Measuring instruments - moving iron type, moving coil, shunts and multipliers - insulation resistance tester, ohmmeter, wattmeter, energy meter.

Direct current generators and motors - construction and operation, field systems, starting and control, losses, faultfinding, outline of regulations.

Alternating current - values of a.c. resistance, inductance and capacitance, A.C. power, power factor correction.

Alternating current generators and motors - construction and operation, starting, single-phase motors, fault finding.

Transformer - self and mutual inductance, construction and operation, losses, cooling, outline of regulations.

Rectification - half and full wave rectification, diode and double diode valves, mercury arc rectifier, metal rectifiers.

Illumination - terms, inverse square law, cosine law, incandescent lamp, low pressure mercury vapour lamp high-pressure mercury vapour lamp, sodium discharge lamp, neon discharge lamp, photometer.

Prevention of accidents - main causes, first aid accident book.

Fixing - fixing motor, fixing in brickwork, hollow partitions.

Electrical maintenance - personal safety, factory regulations, procedure in the event of accidents especially from electrical equipments, safe and efficient use of hand tools, access lifting and moving equipments and manual lifting techniques. Use of measuring instruments. Factory recording procedures - stores procedures, maintenance and breakdown recording procedure and use of factory records.

Installation, servicing and testings of lighting systems, fire alarm and control systems, clock system, simple DC and AC motors, batteries, common heating ventilating plants. Rectification of common electrical faults.

