guidelines for instructors

masterplan-curriculum for apprentices & trainees

electrician

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DEVELOPMENT CELL
FOR SKILLED LABOUR TRAINING
DIRECTORATE OF MANPOWER & TRAINING
GOVERNMENT OF THE PUNJAB
LAHORE

masterplan-curriculum

for

imparting theory instructions

to

apprentices and trainees

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electrician

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C O N T E N T S

I N T R O D U C T I O N

With a view to standardizing skilled labour training, functioning under the aegis of the DIRECTORATE OF MANPOWER & TRAINING, PUNJAB, LAHORE, a Development Cell has been set up at this Directorate under the Pak-German Technical Assistance Programme. One of the activities of the Development Cell is to prepare standardized "Training Courses" for various trades.

Skilled manpower is the backbone of industry. Industrial progress is not possible without the availability of systematically trained skilled personnel. The trade proficiency of such a skilled workman does not only depend upon his skills but also upon the knowledge of when and how to apply these skills in any situation that may arise while working on the job. Therefore, a sound understanding of materials, tools, appliances and working methods is a must for every systematically trained skilled workman and the training programme has to fulfil this requirement.

Although skilled workmen must gain broad background information about their respective trade during the course of training, that does not mean they should be imparted highly scientific theory as for engineers and technicians. Practical work is the prime objective in skilled labour training and theoretical knowledge is required to a lesser extent. As such 80 % of the training period is devoted to practical work and 20 % to that of theoretical instructions.

The Development Cell has therefore prepared the "Masterplan Curriculum" in the subjects of Technology, Technical Mathematics and Technical Drawing for imparting theoretical instructions to apprentices and trainees of the electrical trade. A number of experiments have been worked out as a part of this training in the "Masterplan Curriculum" to emphasize learning by doing.

SET-UP OF THE MASTERPLAN CURRICULUM

The Masterplan Curriculum for electricians covers all the necessary requirements for imparting theoretical instructions to apprentices and trainees in their chosen trade. It can be utilized in all training institutions where related theoretical instructions are imparted to apprentices and trainees.

The curriculum has been split up in three main subjects namely Technology, Technical Mathematics and Technical Drawing. These subjects have been divided into units and sub-units. Within one sub-unit topics are specified which show the contents of the lesson to be taught. This will help the instructors to understand the scope of the lesson.

Technology is the main subject; the other subjects deal with the related aspects of Technology on the same teaching day. An extract from the Masterplan Curriculum is shown below as an example of these parallel activities:

Unit No.	TECHNOLOGY	TECHNICAL MATHEMATICS	TECHNICAL DRAWING
7	DC-GENERATOR & MOTOR		
7.1	Simple DC-Generators -coil in a magnetic field -working principle -construction -excitation -commutating poles	EMF of a Generator - $E = B \times l \times v$	DC-Generator -principle of commutation -angular displacement of neutral axle (Sheets No. 65,66)
7.2	Types of DC-Generators -series generator -shunt generator -compound generator -direction of rotation and current -characteristics	Terminal Voltage (V) -armature resistance (R_a) -armature current (I_a) -calculation of formula: $V = E - I_a \times R_a$	DC-Generator -separately excited -shunt generator -compound generator (Sheets No. 67,68,69)

Every sub-unit has a common serial number for the three subjects namely Technology, Technical Mathematics and Technical Drawing. One sub-unit is to be taught in one day. For TTCs, an additional half day per week may be provided for Laboratory Work (Experiments). One day per week system with 6 - 7 lesson-periods may be followed for imparting theoretical instructions. The break-up of the lesson-periods is as follows:

2 - 3 lesson-periods for Technology
2 lesson-periods for Technical Mathematics
and 2 lesson-periods for Technical Drawing.

HOW TO USE THE MASTERPLAN CURRICULUM FOR THE APPRENTICE TRAINING SCHEME

Under the Apprentice Training Scheme the duration of training for electricians is three years. This time has been divided into six periods/semesters. The theoretical instructions may be arranged on a Day Release Basis throughout the period of training. A Block Release System may also be followed which provides about 150 days (25 weeks) with 6 - 7 lesson-periods per day (for Electrical Theory and Experiments).

The programme of theoretical instructions for apprentices is broadly divided into two parts namely Fundamentals of the Metal Trade and Electrical Trade Theory.

During the first semester a common course for Metal, Auto and Electrician Trades namely "Fundamentals of Metal Trades" is to be taught for the first three months (week 1 - 12) of the semester. During the next three months (week 13 - 24) of the semester "Fundamentals of Electrical Trade Theory" is to be taught which covers unit no. 1 and 2 of the Masterplan Curriculum.

From the second to sixth semesters a sandwich programme for imparting instructions in Electrical Trade Theory (Technology, Technical Mathematics and Technical Drawing) and Laboratory Work (Experiments) have been prepared. Electrical Trade Theory and Experiments are changing in such a way that first the theoretical background is given in Electrical Trade Theory and then the related Experiments are worked out.

At the end of the second to fifth semesters and at the end of sixth semester 2 weeks and one week are provided respectively for the review of the course. One week more is provided at the end of each semester for a test.

The time schedule for imparting theoretical instructions (Trade Theory and Laboratory Work) to apprentices is shown on page no. 6

MASTERPLAN CURRICULUM

TIME SCHEDULE FOR APPRENTICE TRAINING SCHEME

UNIT NO.	TRADE THEORY AND LAB. WORK	WEEK	
	FUNDAMENTALS OF METAL TRADES	1-12	1st SEMESTER
1 - 2	ELECTRICAL THEORY	13-24	
	TEST	25	
1 - 7	EXPERIMENTS	1-7	2nd SEMESTER
3 - 5	ELECTRICAL THEORY	8-18	
8 - 11	EXPERIMENTS	19-22	
	REVIEW	23-24	
	TEST	25	
6 - 7	ELECTRICAL THEORY	1-12	3rd SEMESTER
12 - 21	EXPERIMENTS	13-22	
	REVIEW	23-24	
	TEST	25	
8 - 9	ELECTRICAL THEORY	1-15	4th SEMESTER
22 - 28	EXPERIMENTS	16-22	
	REVIEW	23-24	
	TEST	25	
10 - 13	ELECTRICAL THEORY	1-15	5th SEMESTER
29 - 30	EXPERIMENTS	16-17	
14	ELECTRICAL THEORY	18-22	
	REVIEW	23-24	
	TEST	25	
15 - 18	ELECTRICAL THEORY	1-12	6th SEMESTER
31 - 38	EXPERIMENTS	13-20	
	REVIEW	21-24	
	FINAL TEST	25	

HOW TO USE THE MASTERPLAN CURRICULUM FOR THE TECHNICAL TRAINING SCHEME

Under the Technical Training Scheme the duration of training for electricians is two years. This time (2 years) has been divided into four periods/semesters. The theoretical instructions (Trade Training only) may be arranged on a Day Release Basis throughout the period of training. In addition half a day per week or one day per two weeks may be provided for Laboratory Work (Experiments) from the second semester to the fourth semester.

The programme of theoretical instructions for trainees is broadly divided into two parts namely Fundamentals of Metal Trades and Electrical Trade Theory.

During the first semester a common course for Metal, Auto and Electrician trades namely "Fundamentals of Metal Trades" is to be taught for the first three months (week 1 - 12) of the semester. During the next three months (week 13 - 24) of the semester "Fundamentals of Electrical Theory" is to be taught which covers units no. 1 & 2 of the Masterplan Curriculum.

From the second to fourth semesters Trade Theory (Technology, Technical Mathematics and Technical Drawing) and Laboratory Work (Experiments) have been arranged in such a way that first the theoretical background is given in Electrical Trade Theory and then the related experiments are worked out.

At the end of each semester one week's time is provided for test.

The time schedule for imparting theoretical instructions (Trade Theory and Laboratory Work) to trainees is shown on page no. 8.

MASTERPLAN CURRICULUM

TIME SCHEDULE FOR TECHNICAL TRAINING SCHEME

	1st SEMESTER			2nd SEMESTER			3rd SEMESTER		4th SEMESTER		
WEEK	1 - 12	13 - 24	25	1 - 23	24	25	1 - 24	25	1 - 23	24	25
TRADE THEORY DAY RELEASE BASIS	FUNDAMENTALS OF METAL TRADES	ELECTRICAL THEORY	TEST	ELECTRICAL THEORY	REVIEW	TEST	ELECTRICAL THEORY	TEST	ELECTRICAL THEORY	REVIEW	FINAL TEST
UNIT NO.		1 - 2		3 - 7			8 - 11		12 - 18		
LABORATORY WORK (1/2 day per week or 1 day per 2 weeks)				EXPERIMENT NO. 1 - 11			EXPERIMENT NO. 12 - 26		EXPERIMENT NO. 27 - 38		

BOOKS AND MANUALS

Text Books

1.	Dittrich-Volz	-	"Ibtdai Electrical Engineering" Part I (Urdu Edition) National Book Foundation for: Development Cell for Skilled Labour Trg.
2.	Development Cell	-	"Ibtdai Electrical Engineering" Part II (Urdu Edition) National Book Foundation for: Development Cell for Skilled Labour Trg.
3.	Rongen	-	"Tekneeki Hesab Barai Electrician" (Urdu Edition) National Book Foundation for: Development Cell for Skilled Labour Trg.
4.	Development Cell	-	"Technical Drawing for Electrician General" Book 1, 2, 3 Development Cell for Skilled Labour Trg.
5.	Development Cell	-	"Experiments for Electrician" Development Cell for Skilled Labour Trg.
6.	Schillo	-	"Westermann Tables for Electrician" National Book Foundation for: Development Cell for Skilled Labour Trg.

Reference Books

Maj.J.M.Cheepman	-	"Barqi Rau", Part I, II, III, IV & V National Book Foundation

Instructor Manuals

1.	Development Cell	-	"Solution Book Technical Drawing for Electrician General" Book 1, 2, 3 Development Cell for Skilled Labour Trg.
2.	Rongen	-	"Solution Book Tekneeki Hesab Barai Electrician" Development Cell for Skilled Labour Trg.
3.	Development Cell	-	"Instructor Manual Experiments for Electrician" Development Cell for Skilled Labour Trg.

LIST OF EXPERIMENTS

1. Generation of EMF
2. Ohm's Law
3. Resistance of a wire
4. Loss of voltage on lines
5. Resistance and temperature
6. Series connection of resistances
7. Parallel connection of resistances
8. Electrical power
9. Electrical energy
10. Thermal energy of an electrical current
11. Galvanic cells
12. Permanent magnetism
13. Electro magnetism
14. Residual magnetism
15. Induction voltage
16. Mutual induction (Principle of a transformer)
17. Eddy currents
18. Self induction and inductance
19. Current carrying conductor and coil in a magnetic field
20. DC-Motor
21. Pure inductance in AC
22. Coil in AC
23. Capacitor in DC and AC
24. Series and parallel resonance
25. Three-phase current - star connection
26. Three-phase current - delta connection
27. Extension of measuring instruments
28. Voltage- and current-fault connection
29. Single-phase transformer
30. Squirrel cage motor
31. Slipring motor
32. Single-phase motor
33. Circuits of rectification I
34. Circuits of rectification II
35. Connection of fluorescent lamps
36. Improvement of power factor

Note: For details please see Experiment book for electrician.

MASTERPLAN - CURRICULUM

FUNDAMENTALS OF METAL TRADES

Unit No.	TECHNOLOGY (including Working Techniques (WT), Materials (M) and Science (S)	TECHNICAL MATHEMATICS	TECHNICAL DRAWING	Sheet No.
FM 1	INTRODUCTION			
1.1	WT Workshop, Workplace, Tools -order of workplace -maintenance and storing of tools -costs of machines, tools, materials -introduction to general tools used in the metal workshop; their care and proper use M Basic Characteristics of Metals -metals / non-metals -pure and alloyed metals -ferrous / non-ferrous metals -base metals	Whole Numbers -addition and subtraction	Introduction to Technical Drawing -kinds of lines -drawing instruments	1
1.2	WT Workshop, Workplace, Tools -safety precautions M Important Metals -use of grey cast iron and steel -important non-ferrous metals and their use S Power -muscular power -machine power -sources of power -important prime-movers	Whole Numbers -multiplication and division	Introduction to Technical Drawing -lettering exercises	2,3

Unit No.	TECHNOLOGY	TECHNICAL MATHEMATICS	TECHNICAL DRAWING	Sheet No.
FM 2	MEASURING I			
2.1	WT General Introduction -purpose of measuring -accuracy of measuring -linear measuring (steel rule, calipers, vernier calipers) S Units -units of length (metric) -units of angles	Fractions -addition, subtraction of common fractions	Views of Prismatic Work-pieces I -representation in cavalier projection	4,5
2.2	WT Steel Rules -types and use of different steel rules and steel taps Calipers -inside/outside calipers (construction and use) -transferring measurements and reading on rules S Types of Motion -linear motion -rotary motion -measuring of motion (velocity)	Fractions -proper fractions, improper fractions and mixed numbers -multiplication and division of fractions	Views of Prismatic Work-pieces I -representation in 3 views	6,7, 8,9

2.3	WT Vernier Calipers (inside, outside, depth) -accuracy of reading (metric) -principle of vernier scale -measuring faults Angle Measuring Instruments -measuring with angle measuring instruments (fixed/adjustable)	Decimal System of Measurement -metre, gram, litre	Views of Prismatic Workpieces I -assembling bodies recognition of views	10,11 11A
2.4	WT Care and Maintenance of Measuring Instruments Gauges -purpose and use of thread gauges and feeler gauges	Decimal System of Measurement -multiples and parts of units	Views of Prismatic Workpieces I -completion of views, visible edges	12

Unit No.	TECHNOLOGY	TECHNICAL MATHEMATICS	TECHNICAL DRAWING	Sheet No.
FM 3	HAND-OPERATION TECHNIQUES I			
3.1	WT Marking -necessity of marking -common marking tools (scriber, steel rule, centre punch, marking block, vernier height gauge, centric gauge, centring bell) -marking with common marking tools -care and maintenance of marking tools M Properties of Materials -elementary metals - alloys -crystal structure of metals S Force -effects of force -forces acting at the cutting edge of the tool	Decimal Fractions -addition, subtraction	Prismatic Workpieces I. Dimensioning -workpieces with covered edges	13, 14, 15
3.2	WT Chipping and Cutting by Hand Sawing -cutting principle (rake angle) -the saw blade (pitch of teeth, setting of teeth and tightening the blade in the frame) -sawing of pipes and sheets M Properties of Materials -hardness of materials -effect of hardness	Decimal Fractions -multiplication, division	Prismatic Workpieces II Dimensioning -entry of dimensions	14, 15

3.3	WT Chiselling -purpose of chiselling and its principle -types of chisels and their use -cutting effect of the wedge -chiselling faults and the prevention of accidents S Force -measuring of force and its representation -cutting action of forces	Conversion of Inch to Metric System -equivalent of one inch in mm -conversion of dimensions	Prismatic Workpieces II Dimensioning -drawing true to scale	16,17
3.4	WT Shearing -shearing with hand shears and shearing machines -types of hand shears and their working S Force -forces at levers -lever and its principle -lever in balance	Percentages -meaning of percentage -changing numbers to percents -changing percents to decimal and common fractions	Prismatic Workpieces II Dimensioning -drawing of radii	19

3.5	WT Filing -process of filing -shape of cuts -types of files with regards to cuts and shapes M Properties of Materials -cohesive force in materials (cohesion) -cohesiveness of materials S Strength -tensile/compressive strength	Percentages -finding the rate, the base, the percentage	Prismatic Workpieces II Dimensioning -inclined surfaces	19
3.6	WT Scraping -scraping process -principle of scraping tools (rake angle) -scraping tools and their use Making Holes with -punching tools, punching pliers and press punches S Friction Cutting Force and Cutting Resistance	Revision / Test	Cylindrical Workpieces -centre lines, dimensioning -drawing in less than three views	19 19

MASTERPLAN - CURRICULUM

ELECTRICAL TRADE THEORY

Unit No.	TECHNOLOGY	TECHNICAL MATHEMATICS	TECHNICAL DRAWING
1	WHAT IS ELECTRICITY		
1.1	Definition of Electricity -electricity a natural force -origin of electricity -importance of electricity	Transposition of Equations -exchangeable sides of a scale -addition, subtraction	Symbols of Electrical Circuits -voltage sources -switches -consumers (Sheets No. 20 to 25)
1.2	Electric Charges -positive charge -negative charge -force between similar charges -force between opposite charges	Transposition of Formula -exercises with simple already known formula -addition and subtraction $U = l_1 + l_2 + l_3$	Simple Current Path Diagrams (Sheet No. 26) Types of Diagrams (Sheet No. 27)
1.3	Electricity has its Origin in Matter -conductors -non-conductors -composition of matters -atomic structure -the free electrons as carriers of charge	Transposition of Equation -exchangeable sides of a scale -multiplication, division	Single Pole Switch Circuit (Sheet No. 28)
1.4	Electromotive Force and Electric Current -current is the movement of electrons -E.M.F. -how to produce E.M.F. -types of current -direction of current	Transposition of Formula -exercises with simple already known formula -multiplication and division $A = \frac{l \times h}{2}$	Single Pole Switch Circuit (Sheet No. 29)

Unit No.	TECHNOLOGY	TECHNICAL MATHEMATICS	TECHNICAL DRAWING
2	PRINCIPLES AND THEORY OF DC		
2.1	The Electrical Circuit and Units -the circuit -unit of current -unit of resistance -unit of voltage -measurement of current, voltage and resistance	Magnitudes of Current and Voltage -units and subunits of current, resistance and voltage μA mA A kA MA $\mu\Omega$ mΩ Ω kΩ MΩ μV mV V kV MV	Multicircuit-Switch Circuit (Sheet No. 30)
2.2	The Ohm's Law current depends on -the voltage (I~V) -the resistance ($I \sim \frac{1}{R}$) -Ohm's law $I = \frac{V}{R}$	The Ohm's Law -calculation of current, voltage and resistance $I = \frac{V}{R}$; $V = I \times R$; $R = \frac{V}{I}$;	Two-Way Switch Circuit (Sheet No. 31)
2.3	The Resistance -resistance depends on: material, length, cross-section -specific resistance -conductivity -materials for resistors	The Resistance of a Wire . -calculation of R, l, A by applying formulae: $R = \frac{\varrho \times l}{A}$; $R = \frac{1}{\sigma \times A}$; $G = \frac{1}{R}$; $\sigma = \frac{1}{\varrho}$;	Intermediate Switch Circuit (Sheet No. 32)
2.4	Voltage Drop and Loss of Voltage depends on: -resistance of line or conductor -load current $-V_\ell = R_\ell \times I$ $-V_\ell = \frac{2 \times \ell \times I}{\sigma \times A}$	Voltage Drop and Loss of Voltage -loss of voltage (V_ℓ) -V = terminal voltage - consumer voltage $-V_\ell = R_\ell \times I$; $-V_\ell = \frac{2 \times \ell \times I}{\sigma \times A}$	Meter Connections -voltmeter -ammeter (Sheet No. 33)

2.5	**Resistance and Temperature** -behavior of a resistor in cold and hot state -effect of temperature on resistance -temperature coefficient -PTC and NTC resistance -super conductivity	**Resistance and Temperature** - $\vartheta R = R_{cs} \times \alpha \times \vartheta T$ - $R_{hs} = R_{cs} + (R_{cs} \times \alpha \times \vartheta T)$	**Combination of Different Circuits** -single pole switch -two-way switch -socket (Sheet No. 34)
2.6	**Series Connection of Resistances** -definition of series connection -current in the series connection -total voltage and individual voltage in a series connection -total resistance -ratio of individual voltages to individual resistances	**Series Connection** - $I = I_1 = I_2 = I_3$ - $V = V_1 + V_2 + V_3$ - $R = R_1 + R_2 + R_3$ - $V_1 : V_2 = R_1 : R_2$	**Combination of two Circuits** -current path diagram -wiring diagram -installation layout (Sheet No. 35)
2.7	**Parallel Connection of Resistances** -definition of parallel connection -voltage in a parallel connection -total current and individual currents -total resistance and conductance -ratio of individual currents to individual resistances	**Parallel Connection** - $V = V_1 = V_2 = V_3$ - $I = I_1 + I_2 + I_3$ - $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ - $G = G_1 + G_2 + G_3$ - $I_1 : I_2 = R_2 : R_1$	**Kitchen Installation** (Sheet No. 36)
2.8	**Series - Parallel Connection** -definition -current in a series-parallel con. -voltage in a series-parallel con. -individual current and voltage -total resistance	**Series - Parallel Connection** calculation of -V total and individual -I total and individual -R total and individual	**Livingroom Installation** (Sheet No. 37)

Unit No.	TECHNOLOGY	TECHNICAL MATHEMATICS	TECHNICAL DRAWING
3	POWER AND ENERGY		
3.1	The Electric Power -electric power depends on voltage and current -unit of power -measuring of power by different methods	The Electric Power - $P = V \times I$ - $P = I^2 \times R$ - $P = \frac{V^2}{R}$	Staircase Installation (Sheet No. 38)
3.2	Mechanical Work, Power and Conversion -mechanical work (energy) -mechanical power -conversion of mechanical power and work (energy) into electric power and energy	Mechanical Work, Power and Conversion -mech. work $W = F \times s$ -mech. power $P = \frac{W}{t}$ -relation between electrical and mechanical work and power $1\ W = 1\ J/s = 1\ \frac{Nm}{s}$ $1\ Ws = 1\ J = 1\ Nm$	Sleeping Room Installation (Sheet No. 39)
3.3	The Electric Energy -electric energy depends on electric power and time -unit of energy (Ws, Wh, kWh) -measuring of energy by different methods -calculation of energy costs	The Electric Energy $-W = P \times t$ -charges (C) = W x energy price(p) $-C_{total} = W \times p$ + basic tarif	Time Switch Installation (Sheet No. 40)
3.4	Efficiency -input power -output power -power losses -reasons for losses -calculation of efficiency	Efficiency - $P_{loss} = P_{in} - P_{out}$ - $\eta = \frac{P_{out}}{P_{in}}$ - $\eta = \frac{Q_{out}}{Q_{in}}$	Installation Layout for Building (Sheet No. 41)

Unit No.	TECHNOLOGY	TECHNICAL MATHEMATICS	TECHNICAL DRAWING
4	THERMAL EFFECT OF ELECTRIC CURRENT		
4.1	Current heats up the Conductor -heating effect of current -current density -admissible load for conductors -selection of cross-section	Current heats up the Conductor -current density $J = \frac{I}{A}\ \left(\frac{A}{mm^2}\right)$ -using tables for selecting: cross-section of conductors and fuse wires	Installation Layout for Building (Sheet No. 42)
4.2	The Fuse -purpose of fuses -short circuit -fuse wire -diazed system -fuse cartridge -quick action and delayed fuses	Fuse Effect of Electric Current selection of fuses: -according to consumer requirement -according to wiring requirement -using tables for selecting fuses	Electric Heater Wiring (Sheet No. 43)
4.3	Thermal Energy -thermal energy of electric current -quantity of heat, specific heat -loss of heat -thermal efficiency -conversion of heat energy -heating appliances	Calculation of Produced Heat -quantity of heat Q -specific thermal capacity c - $Q = c \times m \times \vartheta T$ (J) -thermal efficiency $\eta = \frac{Q_2}{Q_1}$ - $W_{el} = V \times I \times t$ (Ws) - 1 J = 1 Ws -calculation of P_{input} (out of m, ϑT, t, c, η)	Hot Plate Wiring (Sheet No. 44)

Unit No.	TECHNOLOGY	TECHNICAL MATHEMATICS	TECHNICAL DRAWING
5	CHEMICAL EFFECT OF EL. CURRENT		
5.1	Electrolysis -distilled water as a non-conductor -conducting liquids -movement of charges in liquids -ions (anions and cations) -quantity of substances deposited -metal plating -manufacturing of records -electrolytic copper	Deposition of Substances due to Electrolysis -equivalent weights of materials per Ah (Z) -amount of substance deposited (m) -$m = Z \times I \times t$.	Connection of Cells to Provide Different Voltages (Sheet No. 45)
5.2	The Galvanic Cell -electrochemical voltage series -materials suitable for a cell -polarisation and depolarisation -dry cell	Rated Values on Battery -internal resistance (R_i) -original voltage (E) -internal voltage drop ($V_i = I \times R_i$) -terminal voltage ($V = E - I \times R_i$)	Battery Testing Devices (Sheet No. 46)
5.3	Connection of Cells and Internal Resistance -series circuit -parallel circuit -original voltage (E) -internal voltage drop (V_i) -terminal voltage (V)	Connection of Cells series connection: -total voltage ($V = n \times E$) -current load ($I = \frac{n \times E}{R_e + n \times R_i}$) parallel connection: -current load ($I = \frac{E}{R_e + \frac{R_i}{m}}$)	Charging and Discharging (Sheet No. 47)
5.4	The Storage Battery -the lead plate battery -chemical transformation -storage of electric energy -practical construction of storage batteries -positive and negative plates -the electrolyte -charging and discharging -inspection and maintenance	The Storage Battery -capacity $C = I \times t$ -number of cells $n = \frac{V}{E}$ -efficiency $\eta = \frac{\text{Ah discharge}}{\text{Ah charge}}$ -charging time $t = \frac{\text{Ah discharge}}{I}$	Intercommunication Set with Batteries (Sheet No. 48)

	TECHNOLOGY	TECHNICAL MATHEMATICS	TECHNICAL DRAWING
6	MAGNETIC EFFECT OF EL. CURRENT	TRIGONOMETRICAL RATIOS	
6.1	Permanent Magnetism -magnetism -magnetic poles, repulsion, attraction -elementary and permanent magnet -magnetic materials -magnetic field -permeability -remanence	Triangles -right-angled triangles -theorem of Pythagoras	Magnetic Lines of Forces -of a permanent magnet (Sheets No. 49, 50)
6.2	Electro Magnetism -field of a conductor -field between parallel conductors -field of a coil (Right thumb Rule) -the magnetomotive force $F = I \times N$ -magnetizing force $H = \frac{F}{l}$ -flux density $B = 1{,}256 \times H$ -magnetic flux $\Phi = B \times A$	Sine and Cosine of an Angle -ratio between perpendicular and hypothenuse -finding sine out of tables -ratio between base and hypothenuse -finding cosine out of tables	Magnetic Lines of Forces -single conductor -parallel conductors -of a coil (Sheets No. 51,52)
6.3	The coil with an Iron Core - Magnetic Circuit -magnetic conductivity $\mu = \mu_o \times \mu_r$ -magnetic flux in a coil filled with iron $\Phi = \mu_r \times B \times A$ -residual magnetism (remanence B_r) -coercive field strength (H_c) -hysteresis loop	Magnetical Calculation -magnetic conductivity $\mu = \mu_o \times \mu_r$ -magnetomotive force $F = I \times N$ -magnetizing force $H = \frac{I \times N}{l}$	Magnetizing Diagrams -drawing a diagram -reading diagrams (Sheets No. 53,54)
6.4	Induced Voltage -movement of a conductor in the magnetic field -direction of current (right hand / generator rule) -Lenz's law -induced voltage by varying the magnetic field -magnitude of induced voltage	Magnetical Calculation -flux density $B = \mu_o \times \mu_r \times H$ -magnetic flux $\Phi = B \times A$	Symbols (Sheet No. 55)

6.5	Mutual Induction (Principle of a Transformer) -induced voltage and magnetic induction -principle of a transformer	The Transformer Ratios -transformation ratio: $r = \frac{N_1}{N_2}$ -voltage ratio: $\frac{V_1}{V_2} = \frac{N_1}{N_2}$ -current ratio: $\frac{I_1}{I_2} = \frac{N_2}{N_1}$	Construction of Transformers -shape of cores -cross-section of a transformer (Sheets No. 56,57)
6.6	Eddy Currents -eddy currents in metal sheets -results of eddy currents -methods to prevent eddy currents: dynamo sheets compressed-iron-powder cores	Magnetical and Transformer Calculation -repetition	On-Off Circuit with Contactor (Sheet No. 58) Interlocking -by switch and contacts (Sheets No. 59,60)
6.7	Self Induction and Inductance -self induction voltage -direction and magnitude of self induction voltage -inductance -unit of inductance -series and parallel connection	Connection of Inductances -unit and subunits of inductance μH, mH, H -series $L = L_1 + L_2 + L_3$ -parallel $\frac{1}{L} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3}$	Sequence Control (Sheet No. 61) Bell Circuit (Sheets No. 62,63)
6.8	Current-Carrying Conductor and Coil in a Magnetic Field -conductor in the magnetic field -direction of rotation (left hand motor rule) -the coil in the magnetic field -principle of a motor -reversing of the direction -force of drive	Force of Drive - $F = B \times l \times I$	Diagrams with Inductances -delayed illumination of glow lamps -ignition of fluorescent lamps (Sheet No. 64)

Unit No.	TECHNOLOGY	TECHNICAL MATHEMATICS	TECHNICAL DRAWING
7	DC-GENERATOR AND MOTOR		
7.1	Simple DC-Generators -coil in a magnetic field -working principle -construction -excitation -commutating poles	EMF of a Generator $E = B \times l \times v$	DC-Generator -principle of commutation -angular displacement of neutral axle (Sheets No. 65,66)
7.2	Types of DC-Generators -series generator -shunt generator -compound generator -direction of rotation and current -characteristics	Terminal Voltage (V) -armature resistance (R_a) -armature current (I_a) -calculation of formula: $V = E - I_a \times R_a$	DC-Generator -separately excited -shunt generator -compound generator (Sheets No. 67,68,69)
7.3	Principle of a DC-Motor -working principle -construction -principle of the starter -armature reaction	Rated and Starting Current -starting current without starter: $I_{max} = \frac{V}{R_a}$ -rated current: $I_{rated\ current} = \frac{P}{V \times \eta}$	DC-Motors -direction of rotation -shunt and series motor with starter (Sheets No. 70,71,72,73)
7.4	Types of DC-Motors -series motor -shunt motor -compound motor -direction -load, speed and torque -uses	Starting Resistor -maximum starting current $I_{start} = 1.5 \times I_{rated\ current}$ -total resistance depends on $I_{starting}$: $R_{total} = \frac{V}{I_{start}}$ -starting resistor depends on R_{total}: $R_{starter} = R_{total} - R_a$	DC-Motors -compound motor -compound motor with regulator and starter (Sheets 74,75)

Unit No.	TECHNOLOGY	TECHNICAL MATHEMATICS	TECHNICAL DRAWING
8	PRINCIPLES AND THEORY OF AC		
8.1	Origin of AC -the coil in the magnetic field -sine curve of the alternating voltage -generation of induced voltage -period T and frequency f -pole pair p and frequency f -instantaneous, effective and maximum values	Basic Quantities -period and frequency $T = \frac{1}{f}$ -frequency of the induced voltage $f = \frac{p \times n}{60}$	Development of a Sine Curve (Sheets No. 76,77) Vector and Line Diagrams (Sheets No. 78,79)
8.2	Ohmic Resistance in AC -sine curve of voltage and current -power curve of an ohmic resistance -active power -vector diagram	Effective Values -effective voltage and current $V_{eff} = \frac{V_{max}}{\sqrt{2}} = 0.707 \times V_{max}$ $I_{eff} = \frac{I_{max}}{\sqrt{2}} = 0.707 \times I_{max}$ -calculation of ohmic resistance in AC $R = \frac{V}{I}$	Representation of I and V -at ohmic load Construction of a Power Curve out of I and V -at ohmic load (Sheets No. 80,81)
8.3	Pure Inductance in AC -variation of resistance from DC to AC -the inductive reactance $X_L = 2\pi f \times L$ -sine curve of voltage and current (lagging 90°) -active power P = 0, reactive power P_r = max -vector diagram	Pure Inductance in AC -angular velocity $\omega = 2\pi f$ -inductive reactance $X_L = 2\pi f \times L$ -reactive current $I_L = \frac{V}{X_L}$	Representation of I and V -at inductive load Construction of a Power Curve out of I and V -at inductive load (Sheets No. 82,83)

8.4	Coil in AC -circuit diagram (R and L) -vector diagram of voltage -apparent resistance (impedance Z) -impedance triangle	Coil in AC -ohmic voltage drop $V_R = I \times R$ -inductive voltage drop $V_L = I x X_L$ -voltage drop across apparent resistance $V = \sqrt{V_R^2 + V_L^2}$ -apparent resistance $Z = \sqrt{X_L^2 + R^2}$; $Z = \frac{V}{I}$ -phase displacement $\cos\varphi = \frac{R}{Z}$ -phase angle φ	Representation of I and V -at inductive plus ohmic load (Sheet No. 84) Power Curve of Ohmic plus Inductive Load (Sheet No. 85)
8.5	The Capacitor -the electric field -the dielectric -the capacitance -units of measurement -types -parallel and series connection	Connections of Capacitors -parallel connection $C = C_1 + C_2 + C_3 + \ldots$ -series connection $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots$	Circuit with Transformer (Sheet No. 86) The Electric Field (Sheet No. 87)
8.6	Capacitor in DC -charging -discharging -behaviour of capacitor in DC	Capacitor in DC -time constant T $T = R \times C$ -charging time t $t = 5 \times T$	Charging and Discharging of a Capacitor (Sheet No. 88) Connection of Capacitors (Sheet No. 89)
8.7	Capacitor in AC -variation of resistance from DC to AC -capacitive reactance $X_C = \frac{1}{2\pi f \times C}$ -sine curve of voltage and current (leading 90°) -active power $P = 0$, reactive power $P_r = \max$ -vector diagram	Capacitor in AC -capacitive resistance $X_C = \frac{1}{2\pi f \times C}$ -reactive current $I_C = \frac{V}{X_C}$	Representation of I and V -at capacitive load (Sheet No. 90) Construction of a Power Curve out of I and V -at capacitive load (Sheet No. 91)

8.8	Capacitor and Resistor in AC -circuit diagram (R and C) -vector diagram of voltage -apparent resistance (impedance Z) -impedance triangle	Capacitor and Resistor in AC -ohmic voltage drop $V_R = I \times R$ -capacitive voltage drop $V_C = I x X_C$ -voltage drop across apparent resistance $V = \sqrt{V_C^2 + V_R^2}$ -apparent resistance $Z = \sqrt{X_C^2 + R^2}$; $Z = \frac{V}{I}$ -phase displacement $\cos\varphi = \frac{R}{Z}$ -phase angle φ	Representation of I and V -at ohmic plus capacitive load -vector diagram -line diagram (Sheet No. 92)
8.9	The Power in AC-Circuit -power factor $\cos\varphi$ -phase displacement φ -apparent power (P_a) -active power (P) -reactive power (P_r) -vector diagram of power	The Power in AC-Circuit -apparent power $P_a = V \times I$ -active power $P = V \times I \times \cos\varphi$ -reactive power $P_r = V \times I \times \sin\varphi$ -power factor $\cos\varphi = \frac{P}{P_a}$ -triangle of power $P_a = \sqrt{P_r^2 + P^2}$	Construction of a Power Curve out of I and E -at ohmic plus capacitive load (Sheet No. 93)
8.10	RLC-Series Circuit and Series Resonance -series connection of resistor, inductor and capacitor -vector diagram of voltage -impedance triangle -resonance case $X_L = X_C$ and $Z = R$ -phase displacement $\varphi = 0$ -power factor $\cos\varphi = 1$	RLC-Circuit and Series Resonance -apparent voltage $V_a^2 = V_{eff}^2 + (V_L - V_C)^2$ -apparent resistance $Z^2 = R^2 + (X_L - X_C)^2$ -in resonance case $X_L = X_C$ and $Z = R$ -resonance frequency $f_{re} = \frac{1}{2\pi\sqrt{LC}}$ -power factor $\cos\varphi = 1$	Connection with Capacitors (Sheet No. 94)

8.11	**Parallel Circuit and Parallel Resonance** -parallel connection of coil and capacitor -vector diagram of current -resonance case $X_L = X_C$ and $Z = R$ -phase displacement $\varphi = 0$ -power factor $\cos\varphi = 1$	**Parallel Circuit and Parallel Resonance** -apparent current $I_a^2 = I_{eff}^2 + (I_L - I_C)^2$ -in resonance case $X_L = X_C$ and $Z = R_{eff}$ -power factor $\cos\varphi = 1$ -resonance frequency $f_{re} = \frac{1}{2\pi\sqrt{LC}}$	**Connections of Capacitance, Inductance and Resistance** -parallel connection -series connection (Sheet No. 95)
8.12	**Power Factor Improvement** -disadvantage of reactive power (P_r) -advantage of compensation -improvement of power factor -phase angle and current before and after compensation	**Power Factor Improvement** -power before compensation $P_1 = V \times I_1 \times \cos\varphi_1$ -power after compensation $P_2 = V \times I_2 \times \cos\varphi_2$	**Vector Diagram of a Compensation**

Unit No.	TECHNOLOGY	TECHNICAL MATHEMATICS	TECHNICAL DRAWING
9	THREE-PHASE CURRENT		
9.1	Generation of Three-Phase Current -internal and external pole machine -angular arrangement of three-phase windings -wave diagram of induced voltages -sum of instantaneous values	Generation of Three-Phase Current -calculations of instantaneous values	Three-Phase Current Line-Diagram (Sheet No. 96)
9.2	Star Connection -connection -line and phase voltage -line and phase current -current in neutral line at balanced and unbalanced load -power in case of star connection	Star Connection - Y voltage $V_L = \sqrt{3} \times V_p$ - Y current $I_L = I_p$ -power $P = 3 \times P_{phase}$ $= \sqrt{3} \times V \times I \times \cos\varphi$ -apparent power $P_a = \sqrt{3} \times V \times I$	Three-Phase Distribution System (Sheet No. 97)
9.3	Delta Connection -connection -line and phase voltage -line and phase current -power in case of delta connection -three-phase power formula	Delta Connection - Δ voltage $V_L = V_p$ - Δ current $I_L = \sqrt{3} \times I_p$ - power $P = 3 \times P_{phase} =$ $\sqrt{3} \times V \times I \times \cos\varphi$ - apparent power $P_a = \sqrt{3} \times V \times I$	Motor and Heater Connection -star connection -delta connection (Sheets No. 98,99)

Unit No.	TECHNOLOGY	TECHNICAL MATHEMATICS	TECHNICAL DRAWING
10	SIMPLE MEASURING INSTRUMENTS		
10.1	The Measuring Systems -the moving iron system -the moving coil system -the electro dynamic system	Errors of Measurement -class of quality -calculation of measurement-errors -consequences for all calculations with electr. magnitudes	Ammeter and Voltmeter to Determine Resistances -high resistances -low resistances (Sheet No. 100) Symbols on Meters and their Meaning (Sheet No. 101)
10.2	Construction of Measuring Instruments -position of use -symbols -class of quality -type of current -damping system -scales and pointers	Extension of the Current Range -repetition: parallel connection and internal resistance of ammeters -calculation of the shunt resistance: $R_{sh} = \frac{R_i \times I_i}{I_{sh}}$ -the extension factor 'n' $R_{sh} = \frac{R_i}{n - 1}$	Internal Connection of a Multirange Ammeter (Sheet No. 102) Internal Connection of a Multimeter (Sheet No. 103)
10.3	Measuring of Current, Voltage and Resistance -measuring of current and extension -measuring of voltage and extension -measuring of resistance (connection for low and high resistance, ohmmeter, measuring bridge)	Extension of the Voltage Range -repetition: series connection and internal resistance of voltmeters -the series resistance: $R_{ser} = R_{total} - R_i$ $R_{ser} = R_i \times (n - 1)$	Internal Connection of an Ohmmeter -scale division (Sheet No. 104)

10.4	**Measuring of Power** -repetition: electro dynamic system -single-phase power -three-phase power (one, two and three wattmeter method)	**Measuring Low and High Resistances** -low resistance: current-error connection - correction: $R_x = \frac{V_x}{I - I_i}$ -high resistance: voltage-error connection - correction: $R_x = \frac{V - V_i}{I_x}$	**Power Measurement in Single- and Three-Phase Supply** (Sheets No. 105,106)
10.5	**Measuring of Energy, Frequency and Power Factor** -functioning of an energy meter -measuring of energy -measuring of frequency -measuring of power factor	**Determination of Power and Power Factor** -calculation of apparent power P_a out of measuring I and V ($P_a = I \times V$ in VA) -calculation of power factor out of measuring I, V and active power P in W single-phase: $P = I \times V \times \cos\varphi$ $\cos\varphi = \frac{P}{I \times V}$ three-phase: $P = \sqrt{3} \times I \times V \times \cos\varphi$ $\cos = \frac{P}{\sqrt{3} \times I \times V}$	**Energy Meter** -single-phase supply -three-phase supply (Sheets No. 107,108)

Unit No.	TECHNOLOGY	TECHNICAL MATHEMATICS	TECHNICAL DRAWING
11	PROTECTIVE METHODS	SELECTION OF CONDUCTORS & FUSES	PROTECTIVE METHODS
11.1	Electrical Accident and Prevention -reason of electrical accident -effect of current on the human body -first aid -precautions	Standardization of Conductors -standardized cross-sections -minimum required cross-sections	Layout Diagram with Particulars of Cables and Fuses (Sheet No. 109)
11.2	Circuit Protection -possible circuit faults (body contact, short circuit, earth faults) -fuses: rewireable, HRC, cartrige -circuit breaker -protection against short circuit -protection against overloading -current surges	Selection of Fuses -load capacity of conductors -quick and slow acting fuses -test currents, tripping times -operating times of fuses and cut-outs -selection of fuses	Protected Appliances on Mains (Sheet No. 110)
11.3	Motor Protective Switches -fuses are unsuitable to protect a motor -thermal tripping switch -overloading protection -short circuit protection -automatic cut-outs	Maximum Earthing and Loop Resistance -breaking current $I_B = 3.5 \times I_{Fuse}$ -maximum earthing resistance (R_E) $R_E = \frac{65\ V}{I_B}$ -loop resistance of the wiring $R_{loop} = \frac{V_{nominal}}{I_B}$	Circuit with Motor Protective Switch (Sheet No. 111)

11.4	Protective Arrangements -without protective earth (protective insulation, protective low voltage, protective transformer) -with protective earth (protective earthing, neutralization, current-operated earth-leakage circuit breaker)	Testing the Loop Resistance -measuring the voltage: phase - earth (V_N) -connecting the phase over a loop resistor to the earth -measuring current and voltage at the loop resistor (V_{N1}) -calculation: $R_{loop} = \frac{V_N - V_{N1}}{I}$	Earthing and Neutralization in Three-Phase Systems (Sheet No. 112) Circuit with Fault Current Protective Device (Sheet No. 113)
12	TRANSFORMERS		
12.1	Single-Phase Transformers -working principle -no-load and on-load operation -power and power factor	Single-Phase Transformers -calculation of $\frac{V_1}{V_2} = \frac{N_1}{N_2}$ $\frac{I_1}{I_2} = \frac{N_2}{N_1}$	Single-Phase Transformer (Sheet No. 114)
12.2	Efficiency of Transformers -losses -short-circuit voltage -short circuit current -efficiency	Single-Phase Transformers -efficiency $\eta = \frac{P_{out}}{P_{out}+P_{Cu}+P_{Fe}}$ -short circuit voltage $v_k = 100 \times \frac{V_k}{V}$ (%) -short circuit current $I_k = 100 \times \frac{I}{v_k\%}$	Tapped Transformer (Sheet No. 115)

12.3	**Special-Purpose Transformers** -auto transformer -low power transformer (bell-, toy-transformer) -welding transformer -instrument transformer (current and voltage transformer)	**Single-Phase Transformers** -calculation tests with current (I_1, I_2), voltage (V_1, V_2), efficiency, losses	**Three-Phase Transformers** -connection diagram (Sheet No. 116)
12.4 and 12.5	**Three-Phase Transformers** -construction -connections -groups and their use	**Three-Phase Transformers** -interlinked voltages -ratios of windings for common vector groups: Y Y $\frac{V_1}{V_2} = \frac{N_1}{N_2}$ Δ Y $\frac{V_1}{V_2} = \frac{N_1}{\sqrt{3} \times N_2}$ -calculation of power $P_{a1} = \sqrt{3} \times V_1 \times I_1$; $P_{a2} = \sqrt{3} \times V_2 \times I_2$ $P_1 = \sqrt{3} \times V_1 \times I_1 \times \cos\varphi$ $P_2 = \sqrt{3} \times V_2 \times I_2 \times \cos\varphi$	**Three-Phase Transformers** -vector diagrams (Sheets No. 117,118) **Instrument Transformers** -connection diagrams (Sheet No. 119)
13	**SYNCHRONOUS GENERATORS**		
13.1	**Construction and Functioning** -rotary field -rotor and stator -performance on load -synchronizing	**Induced Voltage** -frequency $f = \frac{n \times p}{60}$ (Hz)	**Rotary Magnetic Field** (Sheet No. 120) **Synchronizing** (Sheet No. 121)

Unit No.	TECHNOLOGY	TECHNICAL MATHEMATICS	TECHNICAL DRAWING
14	THREE-PHASE ASYNCHRONOUS MOTORS	INDUCTION MOTORS	INDUCTION MOTORS
14.1	Working Principle -rotary field (repetition) -construction (stator, rotor, bearing) -starting current -torque -rotational speed and slip	Operation Values -power consumption and power output -efficiency: $\eta = \frac{P_{out}}{P_{in}}$	Induction Motor -motor connection -direction of rotation (Sheet No. 122)
14.2	Squirrel Cage Motor -construction of rotor -armature types: round-bar cage, double cage, current displacement armature	Operation Values -synchronous speed (n_s) $n_s = \frac{60 \times f}{p}$ -rated speed (n) -slip (s) $s = \frac{(n_s - n) \times 100}{n_s}$	Starting Connections -YΔ start with drum switch (Sheet No. 123)
14.3	Slipring Motor -construction of rotor -starting rheostat -functioning -uses and characteristics	Armature Current -armature frequency (f_a) depending upon: supply-voltage frequency (f) slip (s) -formula: $f_a = f \times s$	Starting Connections -YΔ start with contactors (Sheets No. 124,125) Reverse Connection (Sheet No. 126)
14.4	Starting Methods -without starting device -with rheostat -with star-delta starter	Operation Values -rated current -rated power -formula: $P_{in} = \sqrt{3} \times V \times I \times \cos\varphi$ $P_{out} = \sqrt{3} \times V \times I \times \cos\varphi \times \eta$	Slip-Ring Motor -with starting rheostat (Sheet No. 127)
14.5	Speed Control -slip -pair of poles -frequency		Two-Speed Motors -two separate stator windings -Δ-YY stator connection (Sheets No. 128,129)

Unit No.	TECHNOLOGY	TECHNICAL MATHEMATICS	TECHNICAL DRAWING
15	SINGLE-PHASE MOTOR		
15.1	Squirrel-Cage Motor -three-phase motor on single-phase supply -capacitor type single-phase motor	Review	Single-Phase Motor -three-phase motor on single-phase supply (Sheet No. 130)
15.2	Single-Phase Motor with Auxiliary Winding -construction -functioning -uses	Review	Single-Phase Motor -with auxiliary winding (Sheet No. 131)
15.3	Universal Motor (Commutator Motor) -construction -functioning -uses	Review	Universal Motor (Sheet No. 132)
15.4	Repulsion Motor Split Phase Motor -construction -functioning -uses	Review	Repulsion Motor (Sheet No. 133)

Unit No.	TECHNOLOGY	TECHNICAL MATHEMATICS	TECHNICAL DRAWING
16	RECTIFIERS		
16.1	Circuits of Rectification -single-phase rectification (half wave, full wave, bridge connection) -three-phase rectification (star and bridge connection) -filter circuit	Number of Elements -reverse voltage (V_r) -number of elements per branch(n) -formula: $n = \frac{V_{AC}}{V_r}$ -filter circuit calculations	Rectifier Connection (Sheet No. 134)
16.2	Valve Rectifier -two electrode vacuum valve -mercury-arc rectifiers Metal Rectifiers -copper oxide rectifiers -selenium rectifiers	Rated Values -AC input voltage (V_{AC}) -DC output voltage (V_{DC}) -relation of V_{AC} to V_{DC} for various connections	Three-Phase Rectifier (Sheet No. 135)
16.3 and 16.4	Semiconductor Rectifiers -structure of semiconductor materials -n-type and p-type semiconductor -junction diode -silicon rectifier -germanium rectifier	Loading Capacity -of different elements -of different connections	Valve Rectifiers (Sheet No. 136) Rectifiers with Smoothing Components (Sheet No. 137)

Unit No.	TECHNOLOGY	TECHNICAL MATHEMATICS	TECHNICAL DRAWING
17	ILLUMINATION		
17.1	Basic Concept of Light -spectrum -quantities of illumination Luminous Source -incandescent lamps -halogen lamps	Luminous Calculations -luminous flux of various light sources (Φ in lm) -power input -luminous efficiency $\eta_L = \frac{\Phi}{P}$	Lighting Layout for Buildings (Sheet No. 138)
17.2	Electric Discharge Lamps -discharge in gas -fluorescent lamps -connection of fluorescent lamps -high-pressure discharge lamps -neon lamps	Illumination of Rooms -illuminance (I in lx) -utilization factor ( ) -depriciation factor (1.25) -recommended illuminance for various rooms -formula: $\Phi = \frac{I \times A \times 1.25}{\eta}$	Fluorescent Lamps -measuring connection -lamp with single pole switch (Sheets No. 139,140)
18	POWER GENERATION & DISTRIBUTION	VOLTAGE DROP ON SERVICE LINES	
18.1	Generation -hydroelectric plants -thermal plants -atomic plants	Selection of Service Lines -DC lines: $v_d = \frac{2 \times l \times I}{\varkappa \times A}$ -AC single-phase lines: $v_d = \frac{2 \times l \times I \times \cos\varphi}{\varkappa \times A}$ -three-phase lines: $v_d = \frac{3 \times l \times I \times \cos\varphi}{\varkappa \times A}$	Fluorescent Lamps -three-phase connection (Sheet No. 141)
18.2	Transmission and Distribution -transmission of electric energy -high-voltage circuit-breakers -distribution network -improvement of power factor		Fluorescent Lamps -lead-lag connection (Sheet No. 142)