

MAHARASHTRA STATE BOARD OF VOCATIONAL EDUCATION EXAMINATION, MUMBAI

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---------|--|---|--------|--------|------------|-------------|--|--|--------|------------|-----------------|---------|----------|------------|-------------|---|----------|------------------------------------|------|--------|-----|----|---|----------|---|-------|--------|-----|----|---|----------|--|--------|--------|-----|----|---|----------|------------------------------------|------|--------|-----|----|---|----------|---|-------|--------|-----|----|---|----------|--|--------|--------|-----|----|--|--|-------|--|--|-----|-----|
| 1 | Name of Syllabus | C.C.In Repair, Maintenance And Rewinding Of Electrical Motors (302207) (w.e.f. 2018-19) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | Max. No's of Student | 25 students. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | Duration | 1 YEAR | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | Type | Part Time | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | No Of Days / Week | 6 Days | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | No Of Hours /Days | 7 Hrs | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | Space Required | Lab = 800 Sq feet Class Room = 200 Sq feet TOTAL = 1000 Sq feet | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8 | Entry Qualification | S.S.C. passed | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 | Objective Of Syllabus/ introduction | To enable the students to get skill in Electrical | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | Employment Opportunity | Student can get employment in related establishment. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11 | Teacher's Qualification | Diploma in ELECTRICAL Engg. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 | Training System | Training System Per Week <table><tr><td>Theory</td><td>Practical</td><td>Total</td></tr><tr><td>6 Hours</td><td>18 Hours</td><td>24 Hours</td></tr></table> | | | | | | | Theory | Practical | Total | 6 Hours | 18 Hours | 24 Hours | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Theory | Practical | Total | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 Hours | 18 Hours | 24 Hours | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13 | Exam. System | <table><tr><td>Sr No</td><td>Paper Code</td><td>Name of Subject</td><td>TH/PR</td><td>Hours</td><td>Max. Marks</td><td>Mini. Marks</td></tr><tr><td>1</td><td>30220711</td><td>Elements of Electrical Engineering</td><td>TH-I</td><td>3 hrs.</td><td>100</td><td>35</td></tr><tr><td>2</td><td>30220712</td><td>Repair and Maintenance of Electrical Motors</td><td>TH-II</td><td>3 hrs.</td><td>100</td><td>35</td></tr><tr><td>3</td><td>30220713</td><td>Electrical Maintenance & Workshop Practice</td><td>TH-III</td><td>3 hrs.</td><td>100</td><td>35</td></tr><tr><td>4</td><td>30220721</td><td>Elements of Electrical Engineering</td><td>PR-I</td><td>3 hrs.</td><td>100</td><td>50</td></tr><tr><td>5</td><td>30220722</td><td>Repair and Maintenance of Electrical Motors</td><td>PR-II</td><td>3 hrs.</td><td>100</td><td>50</td></tr><tr><td>6</td><td>30220723</td><td>Electrical Maintenance & Workshop Practice</td><td>PR-III</td><td>3 hrs.</td><td>100</td><td>50</td></tr><tr><td></td><td></td><td>Total</td><td></td><td></td><td>600</td><td>255</td></tr></table> | | | | | | | Sr No | Paper Code | Name of Subject | TH/PR | Hours | Max. Marks | Mini. Marks | 1 | 30220711 | Elements of Electrical Engineering | TH-I | 3 hrs. | 100 | 35 | 2 | 30220712 | Repair and Maintenance of Electrical Motors | TH-II | 3 hrs. | 100 | 35 | 3 | 30220713 | Electrical Maintenance & Workshop Practice | TH-III | 3 hrs. | 100 | 35 | 4 | 30220721 | Elements of Electrical Engineering | PR-I | 3 hrs. | 100 | 50 | 5 | 30220722 | Repair and Maintenance of Electrical Motors | PR-II | 3 hrs. | 100 | 50 | 6 | 30220723 | Electrical Maintenance & Workshop Practice | PR-III | 3 hrs. | 100 | 50 | | | Total | | | 600 | 255 |
| Sr No | Paper Code | Name of Subject | TH/PR | Hours | Max. Marks | Mini. Marks | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 30220711 | Elements of Electrical Engineering | TH-I | 3 hrs. | 100 | 35 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | 30220712 | Repair and Maintenance of Electrical Motors | TH-II | 3 hrs. | 100 | 35 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | 30220713 | Electrical Maintenance & Workshop Practice | TH-III | 3 hrs. | 100 | 35 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | 30220721 | Elements of Electrical Engineering | PR-I | 3 hrs. | 100 | 50 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | 30220722 | Repair and Maintenance of Electrical Motors | PR-II | 3 hrs. | 100 | 50 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | 30220723 | Electrical Maintenance & Workshop Practice | PR-III | 3 hrs. | 100 | 50 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Total | | | 600 | 255 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

THEORY - I

Elements of Electrical Engineering

PART A

1. Basic Electricity

- 1.1 Electrical Potential, Potential difference, Current, Resistance, Capacitance, Work, Power, Energy, their definition and units
- 1.2 Ohm's Law, its application to series, parallel and mixed resistance circuits
- 1.3 Resistivity, specific resistance of conductor, effect of resistance and Temperature Co-efficient of Resistance
- 1.4 Electricity, Sources of electricity, Transmission, Distribution of electricity in brief.

2. Effect of Current

- 2.1 Chemical Effects of Current - Faraday's first and second law of electrolysis, electrochemical equivalent, Types of primary and secondary cells, their comparison study of primary of batteries, Uses of storage battery.
- 2.2 Magnetic effect of current - Definition, classification and properties of magnet. Preparation of Electromagnet and permanent magnet and their comparison.
- 2.3 Definition of magnetic terms - Lines of force, magnetic field, flux, magnetic circuit, reluctance, E.m.f. etc. Comparison between electric and magnetic circuit, magnetic circuit with air gap.
- 2.4 Rules related to Magnetism -Cork Screw Rule, Solenoid definition, End Rule, Helix Rule. Current carrying conductor placed in magnetic field, Right Hand Rule, Lenz's law.
- 2.5 Faraday's laws of Electro magnetism Faraday's first and second law induced EMF self and mutual induction, Eddy Currents, their effects and minimization current carrying conductor placed in magnetic field, right hand rule.

3. Alternating Current (A.C.) Circuits

- 3.1 Advantage of A.C. over D.C.
- 3.2 Generation of A.C. supply simple single phase alternator
- 3.3 A.C. Terms :
 - i) One cycle, amplitude, Time period, Frequency, Wave form, Instantaneous value, Average value, R.M.S. value, In phase, Out of phase, Form factor, Peak factor.
 - ii) Inductance, Inductive reactance, capacitive reactance, Impedance, Relation between X_L , X_C and Z
 - iii) Effects of lagging and leading power factor, True power, apparent power, Power factor.
- 3.4 Types of A.C. Circuits
 - i) Pure resistive, Pure inductive and Pure capacitive circuits.
 - ii) A.C. series circuits R-L, R-C, R-L-C series circuits with vector diagram and examples.
 - iii) A.C. parallel circuits: R-L, R-C, R-L-C parallel circuits with vector diagram and examples.

4. Transformer

- 4.1 Principle of Transformer, Types of Transformer E.M.F. equation of Transformer
- 4.2 E.M.F. ratio, Turns ratio, Current ratio
- 4.3 Examples -To make the ideas clear some examples are to be taken up.

5. Supply System

- 5.1 Generation of Single Phase, Three phase supply system.
- 5.2 Three phase system, Star and delta connection, Balance system, voltage, current and power relation.
- 5.3 Rectification of Supply: Half and full wave rectifier circuits.

6. Study of Measuring Instruments

- 6.1 Introduction of measuring instruments with M.I. and M.C.instruments, Voltmeter, Ammeter
- 6.2 Study of Wattmeter, Multimeter, Megger, Tong tester etc.

PART B

1. A.C. Machines

- 1.1 A.C. winding terminology
- 1.2 Necessity of winding
- 1.3 Division of winding according to the shape of the end turn
- 1.4 Classification of A.C. winding according to the supply of
 - i) Single Phase (ii) Three Phase
- 1.5 Conducting and insulating materials and wire used in A.C. machine winding specification and their materials
- 1.6 A.C. Single Phase winding and its types. Introduction of automatic winding machine
- 1.7 Fundamental definition such as - coil pitch, coil throw, single layer, double layer, pole, frequency, slot, active coil, inactive coil, start and end connections.
- 1.8 Procedure of winding, different types of single phase motor in which taking Name plate data, Inside motor data, such-capacitor start, split phase, universal etc.
- 1.9 i) Whole coil winding
 - a) Balanced winding
 - b) Unbalanced winding
 - c) Full pitch winding
 - d) Fractional pitch winding
- ii) Half coil concentric winding
 - a) Two tier (b) Three tier
- 1.10 Dual Speed Motor Winding
- 1.11 Testing of rewound motor
- 1.12 Three phase motor winding - Procedure of rewinding, different type of three phase induction motors noting name plate data and inside motor data
- 1.13 Connection of coils
- 1.14 Finding out the terminals A1-A2, B1-B2, C1 - C2 by two voltmeter method and lamp methods
- 1.15 Procedure of Varnishing of rewound motor
- 1.16 Connections - (1) Star/Delta (2) Star or Delta
- 1.17 Testing of rewound motor.

2. D.C. Machines

- 2.1 D.C. Winding Terminology
- 2.2 Types of D.C. winding (field and armature winding)
- 2.3 Winding Terms :
 - i) Inductor
 - ii) End Turn
 - iii) Turns
 - iv) Coil
 - v) Coil side
 - vi) Coil lead
 - vii) Coil group
 - viii) Half coil winding
 - ix) Single layer
 - x) Double layer
 - xi) Pole pitch
 - xii) Winding pitch
 - xiii) Back pitch
 - xiv) Front pitch
 - xv) Commutator pitch
 - xvi) Full pitch winding
 - xvii) Chorded winding
- 2.4 Materials used in armature winding such as
 - i) Conducting material
 - ii) Insulating material

- 2.5 Definition of lap winding, wave winding, its uses and its types, like simplex and duplex etc.
- 2.6 Progressive and retrogressive winding its meaning and use
- 2.7 Different types of winding data and its skeleton diagram:
- 2.8 i) Testing of wound armature
- ii) Testing of field winding.

PRACTICAL - I

Elements of Electrical Engineering

PART A

1. Testing of supply A.C. and D.C. by test lamp method and multimeter method
2. Verification of Ohm's law, measurement of resistance in series and parallel circuits by voltmeter ammeter method
3. Magnetic effects of current carrying conductor, Verification of various rules (As given in the Unit 2 of theory)
4. Study and use of megger. Measurement of insulation resistance and continuity
5. Practical of 1) R. and L. in series and in parallel
 - 2) R. and C. in series and in parallel
 - 3) R.L.C. in series and in parallel
 Practical on inductive reactance, capacitive reactance, Impedance, Power, True Power, Apparent Power, Power factor improvement
6. Study of self and mutual induction
7. Connection of Star and Delta system. 3 phase power measurement by single wattmeter and 2 wattmeter
- 8, 9 Study of all types of transformers (i.e. C.T.P.T. and auto. Measurement of primary and secondary voltage. Measurement of primary and secondary current. Simple transformer tests
10. Single and Three phase simple rectification circuits
- 11 Study of the Voltmeter and Ammeter, their construction, methods of use, methods of enhancement and range
12. Small coils rewinding practice - N.V.C
- 13,14. Connection of all meters and safety equipments required for control panel of Three phase Induction Motor
15. Connection of Delta Connected capacitor to 3-ph Induction Motor and circuit parameters measurement
16. Rewinding of synchro Transformer
17. Small toy motor rewinding
- 18, 19 Visits to rewinding shops and factories
20. Study of all types of measuring instruments (i.e. M.I., M.C. etc.)

PART B

A.C. Machines

1. Noting the data of burnt motor (name plate data) and inside data
2. Removing coils or stripping of old winding
3. Noting down coil pitch, turns, gauge, connection and insulating material
4. Cleaning of slots
5. Making a shape from coil of old one in good condition, for a former
6. Preparation of a former as per above old coil
7. Rewinding a coil as per old turns
8. Insulating the slots as per original insulating material
9. Inserting coil in slots
10. Noting down start and end for connection
11. Making a connection as per developed diagram
12. Inserting wedges in slots
13. Assembling a motor and find out Start-End of the terminals
14. Testing of motor
15. Taping, binding and shaping of the coils
16. Baking and varnishing

17. Practice in winding types :
 - i) Stator winding
 - ii) Single layer balanced winding
 - iii) Unbalanced
 - iv) Double layer
 - v) Half coil concentric
 - vi) Dual speed winding
18. Rotor winding - Round and Strip connection
19. Replacement and reconnection of the rotor bars
- 20 Impregnating and Baking

D.C.Machines

21. General winding procedure
22. Noting winding data
23. Disordering of the series connections of the coils
24. Removal of bands and Wedges
25. Noting of the pitch and turns
26. Insulating the slots liner
27. Cleaning the slots
28. Removal of the coils
29. Inserting the coils as per data
30. Connection of coils as per diagram
31. Binding and Taping
32. Soldering the coil terminals to the series
33. Testing of wound armature by growler
34. Trial, assembly and testing
35. Proper shape to the coil

Field Coil

36. Noting the data for field coil
37. Removing the field coils
38. Measure the turns and gauge
39. Making the coil former
40. Winding a new coil on former
41. Taping the coils
42. Inserting the coils and making connections
43. Testing the coils
44. Assembling the field coil on Yoke
45. Practice on Armature Windings:
 - i) Lap Simplex
 - ii) Lap Duplex
 - iii) Wave Simplex
 - iv) Wave Duplex
46. Testing and Running of the armature
47. Impregnating and baking.

THEORY - II
Repair and Maintenance of Electrical Motors
PART A

1. Conducting Materials

- 1.1 Definition of Conductor and Insulator with examples, explanation using atomic theory.
- 1.2 Low Resistivity Materials: Ferrous and non-Ferrous metals. Copper and Aluminum as low resistivity material, their electrical characteristics and applications
- 1.3 High Resistivity Materials: Electric resistance material, Material for brushes, Nicrome, Eureka, Carbon and Electrolyte, their characteristic and application.

2. Insulating Materials

- 2.1 Difference between conductors, semi-conductors and insulators
- 2.2 Insulation resistance, dielectric strength, breakdown voltage, mechanical and physical properties of insulating materials
- 2.3 Classification of insulating materials paper, pressphane, plastic coated paper, empire cloth, Leathered paper, cotton and silk cloth, rubber, P.V.C. porcelain, bitumen mica, Bakelite, Ebonite, Marble, Glass and waste fiber glass etc., their electrical characteristics and application
- 2.4 Insulating tapes, sleeves, varnishes, their application and uses (IS-1271-1958). Transformer oil, insulating material with effect of rise in temperature.

3. Heating, fuse material

- 3.1 Copper, Lead, Tin, Silver and their alloys as fuse materials, their properties and applications
- 3.2 Different types of fuses, their comparison ratings
- 3.3 Soldering, percentage of solder, metal in solder, use of flux, blow lamp, Procedure of soldering and brazing.

4. Lubricants

- 4.1 Types and grades of lubricants, their properties, uses and methods of applications.

5. Insulating paints and varnishes

- 5.1 Insulating paint - study of insulating paint component used as base, solvent, colouring pigment etc.
- 5.2 Varnish - study of varnishes, varnish drying methods - air drying, oven drying heater drying etc.

6. Earthing

- 6.1 Types of earthing methods, material used
- 6.2 Testing
- 6.3 Study of Indian Electricity Rules regarding earthing
- 6.4 Study of A 1 form, Study of Report for electrification.

7. Electrical symbols

- 7.1 Electrical symbols used
- 7.2 Drawing
- 7.3 Blue-print reading.

8. Study of Electric Wiring

- 8.1 Necessity of wiring, wiring accessories, switch, holder, plug, socket, round block, Rawal plug, plug pin etc. their diagram and information
- 8.2 Types and information of wire- V.I.R. wire, C.T.S. wire, P.V.C. wire, Flexible wire, T.R.S. wire
- 8.3 Types of wiring - house wiring, casing and capping wiring, batten wiring, conduit wiring etc. wiring accessories or fitting accessories.

9. Study of Electronic components

- 9.1 Diode, resistors, colour code for resistor, Transistors -PNP, NPN, capacitors etc. their characteristics and uses, full wave and half wave rectifiers, Bridge rectifiers.

PART B

1.1 Advantages, maintenance of motor:

- i) Efficiency
- ii) Life
- iii) Protection

1.2 Maintenance, Merits and Demerits :

- i) Break down maintenance
- ii) Preventive maintenance
- iii) Routine Maintenance

1.3 Maintenance schedule:

- i) Daily
- ii) Weekly
- iii) Monthly
- v) Half Yearly
- v) Yearly

2. Maintenance procedure (Ref. I.S.S. and Manufacturer Instructions)

2.1 Periodic measurement of -

- i) Current
- ii) Voltage
- iii) Temperature
- iv) Vibration of running motor

2.2 Onsite maintenance (Mechanical) :

- i) Visual Inspection of lubrication, foundation bolts, terminal bolts, bearing
- ii) Cleaning of motors
- iii) Inspection of commentators and slip ring

2.3 Onsite maintenance (Electrical) :

- i) Testing of insulation resistance and earth resistance testing
- ii) Dry out of motor - External and Internal (By megger test, test lamp method)

Precautionary measuresiii)

Safety precaution “ON-OFF” line maintenance work permit, isolation of motor from supply mains, discharge of cables, Local earthing of motor terminals.

3. Overhauling Process:

3.1 Dismantling of motor - decoupling and disconnection of motors, removal of motors for repair to workshop

3.2 Pre-disassembly testing and inspection, visual inspection, insulation resistance test

3.3 Disassembly - Marking and removal of end frames, Removal of Rotors- pulling of bearing

3.4 Cleaning and inspection of stator, rotor, commentators, slip ring, carbon brush gears, ventilation system fan bearing, rotor shafts

3.5 Machining of commentators, surface of slipping, replacement of worn-out brushes and their adjustments

3.6 Impregnation of armature windings with varnish and insulation paints, baking of armature before and after impregnation

3.7 Bearing checking and Servicing: Replacement of worn-out bearings, straightening of rotor shafts.

4. Re-assembly of Motor

4.1 Measurement of rotor of diameter, stator, bore, thorough cleaning of rotor and stator surfaces, application and anti rust protective layer varnish films on rotor and stator surface.

4.2 Fitting of bearing on rotor shaft, balancing of rotor (above 5H.P.), fitting rotor in stator housing, checking air gap, free rotation of rotor.

4.3 Electrical test after assembly; polarity, I.R. test, winding resistance test, light test, locked rotor test, H.V. test (1000 volt) for 415 V. Motor.

5. Erection of motor with pump set

5.1 Leveling and aligning

5.2 Connection of power cable after testing, Trial run in coupled condition, checking, direction of rotation, coupling of motor with devices, trial run with load for 12 hours

5.3 Observe any abnormality with the motor.

6. Trouble shooting

6.1 Trouble shooting of single phase motor, three phase motor

6.2 Trouble shooting of A.C. Motor starter.

7. Maintenance records

7.1 History register

7.2 Log book

7.3 Wiring diagram, maintenance scheduled charts

7.4 Failure analysis records.

8. Planning and Estimation

8.1 Man, material, tools

8.2 Time required for maintenance

8.3 Estimation.

9. House keeping

9.1 Housekeeping of tools, equipment, accessories etc.

PRACTICAL II

Repair and Maintenance of Electrical Motors

PART A

1. Identification of conducting materials Copper, Aluminum, Silver, Bronze etc. Study of their physical properties, hardness, conductivity etc.
2. Identification of insulating material. Practice of preparing slot insulation for different voltages
3. Practical on magnetic and non-magnetic materials. Study of the strength of magnetic field and polarity by placing them in a solenoid
4. Insulating varnishes, their use and method of use
5. Practical on making simple conductor / wire joints and soldering them
6. Study of different types of fuses, practicals on uses of different fuses and their current. Fuses as safety device. A simple practical be conducted to emphasis on importance of fuse as safety device
7. Practical on simple wiring, using accessories like switches, distribution boards, indicators, sockets, bus bar, holders, round blocks etc.
8. Practical on earthing - Plate earthing, Pipe earthing, Measurement of earth resistance
9. Practical on use of rigid and flexible pipe, their accessories, preparing conduit fittings for wiring
10. Connecting conduit - flexible pipe from switch board to motor switch. Installation of board in the wall fittings and connecting switch and starter on it
11. Practical on uses of electric cleaning agents such as Kerosene, Petrol, C.T.C., White Petrol, Scrubbing agents like sand paper, emery paper, leather etc.
12. Lug selection and crimping - soldering
13. Overload Relay study, testing and general maintenance - repairing
14. Study of all types of bearings, their material, Practical on bearing fitting on shaft and in housing
15. Study of all types of fuses like H.R.C., Glass etc.
16. Necessity of Starter and other protecting equipments for motors
17. Lubrication technique practice
18. Practice on adjustment of belt tension
19. Familiarization with various types of drives
20. Visits to industries having three phase motors load
21. Study of loose wiring circuit
22. Study of different types of wiring
23. Study and testing of electronic components.

PART B

1. Study and use of megger for checking of insulation resistance of motor and cable
2. Study and use of tong-tester on line measurement of current and voltage
3. Method of discharging the line before disconnection of motor from line
4. Study and use of magnetic field by Ring. Yoke and D.C.supply. Testing continuity of rotor.
5. Methods of removal of motor from foundation
6. Methods of checking motor winding polarity
7. Study and application of Electric Blower
8. Study and application of bearing puller for removal of the bearing
9. Inspection of commutator, slip-ring, and carbon brushes for faults and faults rectification
10. Dismantling and refitting of carbon brushes, commutator and slip-ring
11. Dismantling of motor components
12. Checking and inspection of motor components, in installed conditions. Methods of repairing and replacement of defective components
13. Rotor balancing
14. Use and application of anti-rust varnish on Stator and Rotor lamination surface
15. Refitting of bearing on rotor shaft
16. Inspection of end shield and it's refitting
17. Impregnation and baking
18. Reconnection of the motor
19. Final testing of repaired motor (Insulation resistance, Winding resistance, Light run, megger test etc.)
20. Study of Miniature circuit breaker, Earth leakage circuit breaker. Dismantling of all types of starters of A.C. and D.C. motors.
21. Starting of A.C. motors with
 - i) Manual Star-Delta starter
 - ii) D.O.L. starter
 - iii) Semi-Automatic Star - Delta starter
 - iv) Automatic Star-Delta starter
 - v) Auto-Transformer starter
22. Starting of D.C.motors with
 - i) 3 Point Starter
 - ii) 4 Point Starter
23. Speed control of Slip ring induction motor by external resistance
24. Reversal of direction of A. C.motors:
 - i) Single Phase Motor
 - ii) Three Phase Motor.

THEORY - III

Electrical Maintenance & Workshop Practice

PART A

1. Safety precautions :

- 1.1 Shop discipline, safety measures - mechanical and personnel
- 1.2 Causes and types of electrical fire. Firefighting equipment, and precautions to avoid fire
- 1.3 Causes of Electric shock and precautions to familiarize the student with "Standard Shock Treatment Chart"
- 1.4 Artificial respiration and treatment of electrical shock and burns
- 1.5 First-Aid
- 1.6 Up keeping of Workshop and Machines

2. Layout of shop

- 2.1 Different types of shops, such as repair shop
- 2.2 Winding shop
- 2.3 Assembly shop
- 2.4 Testing equipment, machines and electrical installation.

3. Common Workshop Tools

- 3.1 Description, specification, general care and maintenance of hand tools
- 3.2 Uses of files, hammers, Hacksaw, Chisels, Steel rule, Try square, bench vice, spanner, their specification and grades marking tools
- 3.3 Types of drills, Drilling machines, their proper use, care and maintenance
- 3.4 Use of common carpentry tools like saw, chisels, planes, mallets, sand paper, proper selection of tools and method of use.

4. Drawing of three views of simple machine parts

- 4.1 Drawing Instruments
- 4.2 Isometric views and Orthographic Projections
- 4.3 Wiring diagrams and sketches of various accessories.

5. I.S.I. Symbols

- 5.1 For electric accessories, equipment, meters and their use in winding and wiring diagrams
- 5.2 Practical electrical symbols, circuits and their uses in diagrams

6. D.C. Generator and motor

- 6.1 Constructional details
- 6.2 Connection of D.C. Generator and D.C. motor, Types of D.C. generator and motor
- 6.3 Various control equipment
- 6.4 Commutator, Armature winding
- 6.5 Study of efficiency.

7. A.C. Three Phase Motor

- 7.1 Working principles of (rotating magnetic fields) synchronous and asynchronous (Induction) motor
- 7.2 Construction and characteristics of motors
- 7.3 Generation of torque
- 7.4 Speed of A.C. Motor, synchronous speed, rotor speed, slip and its relation
- 7.5 No load and full load speed, torque speed variation, reversing direction of rotation of induction motor
- 7.6 Construction of rotor, Squirrel cage Induction motor (single and double), Slip ring Induction motor.

8. Starting and running of A.C. Motors

- 8.1 D.O.L. starter
- 8.2 Star Delta starter
- 8.3 Auto Transformer starters
- 8.4 Rotor resistance starter
- 8.5 Single phasing, its effect and prevention in three phase motors.

9. Study of single phase motors:

- 9.1 Working Principle
- 9.2 Construction
- 9.3 Types of single phase motors.
- 9.4 Split phase motor
- 9.5 Capacitor motors
- 9.6 Shaded pole motor
- 9.7 Universal motor
- 9.8 Repulsion motor.

10. Study and fault finding of electric domestic appliances

- 10.1 Fluorescent tube
- 10.2 Electric iron
- 10.3 Mixer / Grinder
- 10.4 Electric stove
- 10.5 Heater
- 10.6 Electric fans
- 10.7 Ovens
- 10.8 Electric geyser
- 10.9 Motor in washing machines.

PART B

1. A.C. Single Phase Motor

- 1.1 Working principle, construction
- 1.2 Starting methods
- 1.3 Various types, constructional details, working characteristics of split phase, shaded pole, capacitor start, capacitor run, repulsion induction motor
- 1.4 Universal motor - Characteristics and application
- 1.5 Speed variation and reversal of rotation.

2. Control Circuits

- 2.1 Various basic controls
- 2.2 “ON-OFF” remote, interlock, inter linking, jogging
- 2.3 Timers, necessity and requirement of control circuit with respect to the power or main circuit, outline of main circuit, contacts, N.V.coil, O.L.Coil, O.L.contacts, Limit switches, pressure switch, timers and its application of control, circuit in Starters
- 2.4 D.O.L. starters
- 2.5 Star Delta starters
- 2.6 Auto-Transformer starters
- 2.7 Rotor Resistance starters
- 2.8 Stepped control etc.

3. Pumps

- 3.1 Reciprocating pump, Principle of operation, Single and double acting pumps and their applications
- 3.2 Centrifugal pumps :
 - a) Principle of operation of centrifugal pumps
 - b) Their types and application
 - c) Types of impellers, layout accessories, starting of centrifugal pumps
 - d) Suction head
 - e) Delivery head and total head
 - f) H.P. required to drive the particular pumps with its capacity
- 3.3 Submersible pumps, operating principle of submersible pump, their types and application
- 3.4 Multi-stage pump for higher capacity
- 3.5 Size and No. of Impellers in centrifugal pumps, Loss of Head Pipe Lines and Pipe Fittings, Different parts and materials used in submersible pumps, Testing of submersible pumps and motor, Repairs, fault finding and maintenance of submersible pumps.

4. Pump Fitting

- 4.1 Types of pipes, used in water lifting machines
- 4.2 Different types of accessories used in water lifting machines
- 4.3 Study of ISI Code Nos. of pipes and pipe accessories
- 4.4 Study of Lift Irrigation Scheme.

PRACTICAL - III

Electrical Maintenance & Workshop Practice

PART A

- 1. Study of the layout of machines, workshop equipments and electrical installation. Free hand sketches of workshop layout be made
- 2. Practicals of separating a person in contact with live wire, practical on artificial respiration and shock treatment
- 3. Practical on first aid and use of first-aid box
- 4. Use of different types of fire extinguishers, fire fighting aid and their uses
- 5. Study of different types of files, small jobs involving use of files such as making key, filling a key way for the motor pulley
- 6. Making simple carpentry wood joints and preparing a former for winding coils
- 7. Use of the common tools and instruments, such as soldering iron, calipers, pliers, hammers etc.
- 8. One sheet on Orthographic projection
- 9. Two sheets : drawing simple machines or parts related to electrical fittings and equipments

10. One sheet on Isometric projection
11. Identification of terminals by measuring resistance of armature and field coils in D.C. motor
12. Connection of D.C. motor to suitable starter
13. Changing the direction of rotation of above motor
14. Speed control of D.C. motor - above normal - below normal
15. Identification of 6 leads of any induction motor by test lamp method of continuity checking. Identification of start and End leads of Three-phase induction motor by 2 lamp or 2 voltmeter method
16. Connection of Star and Delta, measurement of voltage between 2 phases, phase and neutral
17. Connection of A.C. Three - phase motor to
 - i) D.O.L. Starter
 - ii) Semi automatic starter
 - iii) Automatic starter
 - iv) Star-Delta Starter
 - v) Auto Transformer Starter
 - vi) Rotor Resistance Starter
18. Finding out percentage slip of the motor by N_s and N_r method
19. Changing direction of rotation of Three-phase Induction motor. Practicals of different method
20. Speed changing of A.C. 3-ph motor by changing number of poles
21. Load testing by break pulley
22. Identification of terminals of single phase motor by measuring resistance of different windings (Starting winding - Running winding)
23. Connect, run and reverse the
 - i) Split phase Induction Motor
 - ii) Capacitor Motor
 - iii) Shaded Pole Motor
 - iv) Universal Motor
24. Locating faults in single phase motor and correcting them
 - i) Break in winding
 - ii) Break in regulator
 - iii) Faulty centrifugal switch
 - iv) Mechanical faults.
25. Study of all domestic appliances.

PART B

1. Study of winding resistance of starting and running winding. Centrifugal switch and its operation, reversal of direction of rotation
2. Study of Split phase motor and Capacitor start and run motor Capacitor testing
3. Study of repulsion motor, speed control, reversal of direction of rotation and torque
4. Opening the Shaded Pole fan motor i.e. study of oscillating mechanism
5. Study of Universal motor - starting with load - Study of double geared motor - electrical Portable Drilling Machine
6. Study of control circuit accessories preparation of simple circuits
7. Study of D.O.L. Starter
8. Star-Delta starter study - Semi Automatic, Fully Automatic
9. Study of Auto Transformer Starter used for lift, irrigation motors (Actual visit to any site having same type of machineries)
10. Repairing of various types of starters
11. Rewinding of number of volt coil of starter
12. Cutting and threading of different types of pipes
13. Fitting of different accessories to the pipe line fitting and maintenance of different types of pressure release and non-return valve
14. Connecting a pipe line to suction and delivery of the pump
15. Fitting of different types of Foot-valves with different types of pipes such as Cast iron pipe, Cement pipe, Asbestos Cement pipe, PVC pipe etc. Study of air leakage

16. Alignment of motor pumps
17. Rewinding procedure of submersible pump
18. Connection of rewound submersible pump
19. Testing of rewound submersible pump
20. Connecting a rewound submersible pump to a given supply
21. Fault finding and repairing of submersible pump
22. Installation and connection of electric motor with pumps
23. Visit to different plants and factories
24. Periodical maintenance of pump set
25. Dismantling and reassembling of Centrifugal and Submersible Pumps
26. Study of Dry Run Protector for protection of water pump.

List of tools and Equipment

EQUIPMENT

| | |
|--|----|
| 1. External Growler 250 V. suitable up to 150 M.M. diameter armature | 01 |
| 2. Internal Growler 250 V. suitable up to 350 M.M. Diameter armature | 01 |
| 3. Universal Growler 250 V. 50 HZ A.C. | 01 |
| 4. Coil winding machine with counter and clutch arrangement | 02 |
| 5. Armature winding machine with counter and clutch arrangement | 02 |
| 6. Impregnation plant opera table on 230 V.50 HZ.A.C. | 01 |
| 7. Drying oven with thermostat | 01 |
| 8. Dummy Stators | 06 |
| 9. Dummy Rotors | 06 |
| 10. Dummy Armature | 06 |
| 11. Dummy yokes with pole shoes | 06 |
| 12. Pillar drilling machine opera table on 230 V.50 HZ A.C. | 02 |
| 13. Bench drilling machine opera table on 230 V.50 HZ A.C. | 02 |
| 14. Bench grinder opera table on 230 V 50 HZ A.C. | 02 |
| 15. Squirrel cage induction motor three phase 400 V 50 HZ A.C. 1440 RPM, 3HP | 02 |
| 16. D.O.L. starter three phase 400 V. A.C. suitable for three phase motor | 04 |
| 17. Squirrel cage induction motor three phase 400 V 50 HZ A.C. 1440 RPM, 3HP | 02 |
| 18. Star Delta starter suitable for 3 phase 400 V. 3 phase 5 HP motors | |
| i) Manually operated | 02 |
| ii) Semi Automatic | 02 |
| iii) Automatic | 02 |
| 19. Capacitor motor single phase 230 V 50 HZ 0.5 HP, 1450 RPM | 02 |
| 20. Miniature Moulded Circuit Breaker | 06 |
| 21. Universal Motor 230 V, 200 to 250 W | 02 |
| 22. D.C.Shunt Motor 220 V, 3 HP | 02 |
| 23. D.C.Three Point Starter suitable for 220 V, 3 H.P. Motor | 02 |
| 24. D.C.Four Point Starter suitable for 220 V, 3 H.P. Motor | 02 |
| 25. D.C.Compound motor 220 V., 3 H.P. | 02 |
| 26. Field Regulators for 3 H.P., D.C.Motors | 02 |
| 27. Field Regulators for 5 H.P., D.C.Motors | 02 |
| 28. D.C.Series Motors for 220 V, 3 H.P. with suitable two controller | 02 |
| 29. A.C.Ceiling fan with regulator 230 V, 1200 MM | 04 |
| 30. A.C.Table fan with regulator 230 V. | 04 |
| 31. A.C.Exhaust fan 230 V., 450 mm | 04 |
| 32. A.C.Three phase Dual speed motor 400 V, 50 Hx, 1475/750 RPM 5 H.P. with suitable starting controlling and preventive equipment | 02 |

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| 33. A.C.Single phase 250 V, 50 Hx, 1475/2550 RPM 0.5 H.P.Duel speed motor with suitable starting, speed selection, controlling and preventive equipment | 02 |
| 34. Water lifting pumps, opera table on 230 V, 50HZ, 12 mm capacity 04 | |
| 35. Dimmer stat, Single phase, 0-270 V, 50 Hz, 1 KVA | 02 |
| 36. Dimmer stat, Three phase, 0-500 V, 50 Hz, 3 KVA | 02 |
| 37. Dimmer stat, Three phase, 0-500 V, 50 Hz, 5 KVA | 02 |
| 38. Shaded pole, motor 230 V, 50 Hz, 120 w | 02 |
| 39. Capacitor Start and Run Motor, 230 V, 50 Hz, 1/4 HP | 02 |
| 40. Semi Automatic Starter, 3 Phase, 400 V, 50 Hz, suitable for 5 H.P. squirrel Cage motor | 02 |
| 41. Selector switch 400 V, 10 amps, assorted | 02 |
| 42. Thermal Over-Load Relay 0=6 | 06 |
| 43. Pulleys with in-built breaking arrangements | 02 |
| 44. Rectifier static with an input of 400 V, 50 Hz, A.C. and output of 25 amps D.C. at 220 V. with all control and preventive arrangements mutual clad, mounted on castor wheels | 02 |
| 45. Rheostat (Variable) : 20 Ohms, 10 amps | 02 |
| 46. Knife switches 60 amps: | |
| A) DPST | 02 |
| B) DPDT | 02 |
| C) TPST | 02 |
| D) TPDT | 02 |
| 47. Various types of Contactors: | |
| A) Opera table on 230 V, 50 Hz, A.C. | 10 |
| B) Opera table on 400 V, 50 Hz, A.C. | 10 |
| C) Opera table on 220 V, D.C. | 10 |
| D) Protective Over-Load Relays for types of contactors with NO - NC | 10 |
| 48. Capacitors Electrolytic 16 Microfarads, 400 V | 05 |
| 49. Choke coils 50,100,150 and 200 Milli-seris 2 amps | 2 each |
| 50. Air-cored solenoid 5 amps | 02 |
| 51. Transformer single phase 230/110 V, 50 Hz, 1 KVA | 02 |
| 52. Battery charger opera table on 230 V, 50 Hz, supply with an output of 15 V, 10 amps, with ampere meter range, selective, control and preventive accessories | 02 |
| 53. Nickel - Iron Accumulator 6 V, 200 A. H.R. | 06 |
| 54. Wound rotor Induction Motor 5 H.P. 400 V, 50 Hz, 1450 RPM, A.C. with external rotor starter and stator Starter with protective accessories. | 02 |
| One of the following of suitable capacity pump be purchased | |
| i) Centrifugal pump | |
| ii) Reciprocating pump | |
| iii) Submersible pump | |
| iv) Multi Stage pump. | |
| TOOLS | |
| 1. Screw Driver Plastic Handle 100 mm, 150 mm, 250 mm | 10 each |
| 2. Screw Driver off-set 100 mm, 150 mm, 200 mm, 250 mm | 10 each |
| 3. Screw Driver Philips type | 10 |
| 4. Ratchet Screw Driver | 10 |
| 5. Connector Screw Driver | 10 |
| Sr. Items Quantity | |
| 6. Pliers combination insulated 150 mm, 200 mm | 10 each |
| 7. Pliers side cutting insulated 150 mm, 200 mm | 10 each |

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| 8. Pliers long nose insulated 100 mm, 150 mm | 10 each |
| 9. Pliers flat-nose insulated 100 mm, 150 mm | 10 each |
| 10. Circlip Pliers | 02 |
| 11. Hammer with wooden handle B.P. | 10 |
| 12. Hammer with handle copper | 02 |
| 13. Hammer with handle Plastic | 02 |
| 14. Carpenter's Saw 350 mm | 02 |
| 15. Tennon Saw 250 mm, 350 mm | 02 |
| 16. Hack Saw adjustable 300 mm | 20 |
| 17. D.E.Spanner Set (Metric) | 2 sets |
| 18. Ring Spanner Set (Metric) | 2 sets |
| 19. Box Spanner Set (Metric) | 2 sets |
| 20. Adjustable pipe wrench 350 mm | 02 |
| 21. Slide wrench 200 mm | 02 |
| 22. Alley key set (Metric) | 2 sets |
| 23. Hand vice 100 mm | 02 |
| 24. Bench Vice 150 mm, 200 mm, Jaws | 2 each |
| 25. File Flat Bstd. 150 mm, 250 mm | 4 each |
| 26. File Flat second cut 150 mm, 200 mm, 250 mm | 2 each |
| 27. File Round 150 mm, 200 mm | 2 each |
| 28. File Half Round 150 mm, 200 mm | 2 each |
| 29. File Triangular 100 mm, 150 mm | 2 each |
| 30. Electrical Soldering Iron 250 V, 60 W, 120 W, 200 W, 150 W | 2 each |
| 31. Electrical Soldering Gun 250 V | 2 each |
| 32. Hand Operated Solder less crimping pliers | 02 |
| 33. Hand Operated Solder less crimping tools with suitable crimping lies | 01 |
| 34. Blow lamp 1 liter capacity and 1.5 liter capacity | 3 each |
| 35. Solder Melting Pot | 02 |
| 36. Laddle tool | 02 |
| 37. Hand drill Machine 6 mm capacity | 06 |
| 38. Portable Electric Drill Machine 250 V, 6 mm capacity | 02 |
| 39. Spring Balance 1 kg, 2 kg, and 5 kg capacities | 1 each |
| 40. Out- side micrometer 0.25 mm | 02 |
| 41. Standard wire gauge | 02 |
| 42. Universal spirit level | 02 |
| 43. Feeler gauge (Metric) | 02 |
| 44. Electrician's knife double blade | 20 |
| 45. Straight Edge snip 200 mm and 250 mm | 02 |
| 46. Bent Edge snip 200 mm and 250 mm | 02 |
| 47. Scissors 200 mm | 06 |
| 48. Tweezers 150 mm | 06 |
| 49. Copper Rod 300 mm x 25 mm, 300 mm x 37 mm | 2 each |
| 50. Centre Punch | 06 |
| 51. Crow Bar of suitable size | 02 |
| 52. Cold chisel 12 mm x 300 mm and 25 mm x 350 mm | 6 each |
| 53. Grease Gun | 02 |
| 54. Oil can | 04 |
| 55. Bearing puller suitable up to 5 H.P. motors | 02 |
| 56. Pulley puller suitable up to 5 H.P. motors | 02 |
| 57. Screw Extractor | 02 |
| 58. Tap and Die set (Metric) | 02 |
| 59. Wire insulation stripper | 20 |
| 60. Oil stove / Blow lamp | 04 |

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| 61. Wire cutter | 20 |
| 62. Steel scale 600 mm (2 ft) | 20 |
| 63. Pipe vice 50 mm dia | 04 |
| 64. Firmer chisel with handle 6 mm, 12 mm, 20 mm and 25 mm | 4 each |
| 65. Rawl plug tools with bit No. 6 and 8 | 2 each |
| 66. Masonry Bits 8 mm | 06 |
| 67. Wooden Mallet | 04 |
| 68. Try square 150 mm | 06 |
| 69. Twist Drills 6 mm, 9 mm | 3 each |
| 70. Gas Pliers 200 mm | 04 |
| 71. Jack Plane 2" cutter | 02 |
| 72. Safety Goggle (plain) | 20 |
| 73. Wood marking tool | 02 |
| 74. First Aid Box | 01 |
| INSTRUMENTS | |
| 1. Ammeter M.I.Type, Multi range: 0-1-2-5-5 amps dial portable (150 mm) | 04 |
| 2. Ammeter M.I.Type, Multi range: 0-5-10-15 amps dial portable | 04 |
| 3. Milli ammeter M.C. Type Multi range 0-500-1000 portable, 100 m dial | 04 |
| 4. Voltmeter, M.I.Type Multi range 0-150-300-600 V, 200 m portable | 04 |
| 5. Voltmeter M.C.Type 0-150 V, 100 mm dial portable | 04 |
| 6. Multimeter / AVO meter, portable | 06 |
| 7. Wattmeter Dynamo meter type 1500/200 mm dial | |
| Multi range 0-1250-2500 V, 5/10 A portable 0-250-500 V | 04 |
| 8. Clip-on-Ammeter (Tong Tester) 0-30-300 A, 0-600 V | 02 |
| 9. Insulation Tester (Megger) 500 V/ 1000 V | 2 each |
| 10. Earth Resistance Testing set | 02 |
| 11. Galvanometer D.C. Centre Zone | 02 |
| 12. Decade Resistance Box (Units-tens-hundred-thousands) | 04 |
| 13. Post Office Box | 02 |
| 14. Wheat stone bridge (1-1000 ohms) | 01 |
| 15. Current Transformer 10/5A 5 VA, 1 Phase, 50 Hz | 03 |
| 16. Energy meter, 1-phase, 50 Hz, A.C. 5 amps | 01 |
| 17. Ammeter 0-15-30 amps, M.I.type Portable | 01 |
| 18. Tachometer suitable for measuring up to 6000 RPM with lowering arrangement | 01 |
| 19. Stroboscope for speed measurement | 01 |
| 20. Phase sequence Indicator | 01 |
| 21. Vibraster | 01 |
| 22. Magnetic Clamps | 06 |
| 23. Thermostat - 0 - 100 C | 02 |

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