ELECTRICITY AND ELECTRONICS (866)

The syllabus is not intended to be used as a teaching syllabus, or to suggest teaching order. It is expected that teachers will wish to develop the subject in their own way.

In the examination, questions will be aimed more at testing the candidates' understanding of fundamental principles, and the application of these principles to problem situations, than to their ability to remember a large number of facts. Some questions will include simple calculations.

An experimental approach to the subject is envisaged and it is assumed that candidates will spend adequate time on individual experimental work. Questions may be set requiring descriptions of experimental procedures. Candidates should also know how to exhibit the results of experiments graphically and how to make deductions from graphs, e.g. from intercepts and gradient in the case of straight-line graphs, deductions by interpolation.

Candidates will be expected to be conversant with SI units.

CLASS XI

There will be one paper of three hours duration of 100 marks.

The paper will be divided into two parts.

***Part I**: will consist of short answer questions. This part will be compulsory.*

***Part II**: will consist of **eight** questions. Candidates will be required to answer **five** questions.*

1. Introduction to electricity. Structure of atoms; the model atom, nucleus, electrons. Unit of charge; coulomb. Potential difference and electromotive force. Production of electricity by friction, magnetism and chemical action.
2. Electric circuit. Electric current I = Qt. Ampere as rate of flow of charge. Ohm's law as applied to a single resistance (V/I=R) and to a whole circuit (E/I= total R).
3. Equivalence. Cell groupings. Resistances in series and parallel. Resistivity; R = Pl/A. Calculation of resistance of wire. Temperature coefficient of resistance. Ammeter shunts; voltmeter multipliers; series ohmmeter.
4. Work, power and energy. Work and energy. The joule. E =V/t (QV). Unit of power and energy; the watt, the kilowatt, the watt-hour and kilowatt-hour. Use of wattmeter. Calculation of electrical energy and power. Local tariff system.
5. Heating effect of an electric current. Application of heating effect, e.g. heating appliances, filament lamps, electric welding, electric carbon arc, and use of fuses.
6. Chemical effect of an electric current. Electrolytes and non-electrolytes. Elementary phenomena of electrolysis, including the electrolysis of acidified water, and of copper (II) sulphate solution using copper or platinum electrodes. The factors affecting the mass of substance liberated in electrolysis and the measurement of current by voltameter (coulometer). Primary cells; Leclanche cell; polarization; local action. Accumulators; construction and characteristics of lead-acid cell; techniques of testing and charging batteries; care and maintenance.
7. Electromagnetism. Simple phenomenon of magnetism. Ferromagnetic properties of iron and steel. Magnetic effect of an electric current. The magnetic field associated with a current flowing in a straight wire, a circular coil, and a solenoid. Force on a current-carrying conductor in a magnetic field; the right-hand and corkscrew rules. Magnetic flux density. Permeability.
8. Electromagnetic induction. Phenomenon of electromagnetic induction. Faraday's law; Lenz's law. Induced e.m.f.; a straight conductor cutting flux; $E = - d\varphi/dt = Blv$. Self-inductance; $E = - Ldi/dr$. Mutual inductance; the induction coil.
9. Elementary electrostatics. Electric field; E = V/d. Capacitance and the factors affecting capacitance. Electric flux density; D = Q/A. Permittivity;

m = D/E. Energy of charged capacitors in series and in parallel.

10. Alternating current. Generation of an a.c. with a single loop coil. Sinusoidal wave form. Peak values; r.m.s. values (Only ratios will be expected.) Simple a.c. circuits.

11. Transformer. Principle of the single-phase transformer, and iron loss (hysteresis and eddy current).

12. Lighting. Common types of lamps; candela, lumen, lux, lux meter (light-meter). Illumination and photometry. Gas-filled lamps and fluorescent lamp circuits; preheat, instant and rapid starts.

CLASS XII

There will be one paper of three hours duration of 100 marks.

The paper will be divided into two parts.

***Part I**: will consist of short answer questions. This part will be compulsory.*

***Part II**: will consist of **eight** questions. Candidates will be required to answer **five** questions.*

1. Distribution of electric power. Idea of a simple distribution system. Mention of the local power system should be made.

   Overhead and underground cables: advantages and uses. D.C and A.C distribution systems: D.C 2 wire system, 3 wire system; AC distribution transformer (3 phase 3 wire system, 3 phase 4 wire system).

2. The D.C. generator and motor. Use of split-ring commutators; constructional features. Shunt series and compound field connections and their characteristics. Starting of D.C. motors. Ideas on back e.m.f.

   Single loop D.C. generator (circuit diagram); parts of a practical generator, lap and wave windings of armature conductors; armature reactions, commutation and period of commutation (T_c), use of interpoles, emf equation $E_g = \frac{\varphi PN}{60} \times \frac{Z}{A}$ *(derivation not required); types of generators; Excitation of poles: Self-excited and separately excited; generator construction: shunt, series & compound types; no-load and load characteristics, voltage, current and power equations, critical resistance; causes of failure to build up voltage for generators, applications and simple numericals.*

   Motors: Working principle of a DC motor; voltage equation; significance of back emf; D.C motor characteristics. Types of D.C motor constructions- shunt, series and compound; necessity of motor starter and protective devices; power equation applications, uses and numericals.

3. The A.C. motor. Ideas on A.C. motors (single phase only). The rotating field. Methods of shunting: capacitance start, split phase start. Single-phase induction motor types.

   A.C. motors (single phase only); idea of rotating magnetic field: split phase start, capacitor start single phase induction motor types. Uses of AC motors.

4. Wires, cables and electrical wiring. Construction of various types in domestic and industrial use. (Solid and stranded cables – how insulated and protected. Flexes). Selection of cable sizes, voltage drop and simple calculation on current-carrying capacity. (Linking of size of cables and flexes with maximum current flow particularly in relation to the circuits below. Regulation B 23 (voltage drop). Brief description of the wiring systems. Simple circuitry. (Separation of lighting and power circuits. Layout of lighting circuits. Switch in phase line. Dual switching of lamps. Layout of power circuits - ring and spur*/ tree systems.)* types - limitations). Introduction to rules and regulations, both local and that of I.E.E. (Sequence of equipment). Effects of overloading. Protection of circuits and individuals by (a) fuses and trips, (b) earthing of metal, (c) mechanical protection of cables. Regulations for bathrooms. Commonsense appreciation of dangerous practices (Simple testing).

Different types of insulations used in cables; Vulcanised Indian Rubber (VIR), Tough Rubber Sheathed (TRS), Poly Vinyl Chloride (PVC).

5. Electrical accessories. Structure and uses of various types of switches, power outlets, lamp holders, ceiling roses and junction boxes. (Familiarity with these is expected - detailed knowledge of structure is not required). Where and how they are used.

   Structure and uses of switches; types: quick break knife switch, main switch, metal clad switch, air break switch, tumbler switch, piano-key switch, finger touch switch; essential qualities of a switch and its position in circuits and layouts; power outlets – Plug and Sockets; lamp holders types: bracket holder, batten holder, pendant holder, angle holder. Ceiling roses; junction boxes. Where and how they are used.

6. Introduction to electronics. Concept of electron flow. Common components employed in electronic circuits; resistors, capacitors and inductors; their structure, types and uses.

   Concept of electron flow; passive components employed in electronic circuits. Types of Resistors: wire wound, carbon composition type, variable type (potentiometers, rheostat); colour code. Types of Inductors: air core, iron-core, ferrite core inductors. Types of Capacitors: fixed and variable types. Fixed type: electrolytic capacitor, non-electrolytic (paper capacitors, mica capacitor, ceramic capacitors); variable type - ganged capacitors, their structure, types, voltage equations and uses.

7. Diodes. Thermionic diode; semiconductor diode. Structure of vacuum diode and semiconductor diode.

   Thermionic diode: construction, operation characteristics of vacuum diodes; A.C and D.C plate resistances, space charge, space charge limiting region.

   Semiconductor diodes: bonds in semiconductors, crystal structure of Germanium and Silicon; effect of temperature on semiconductor; concept of hole current; intrinsic and extrinsic semiconductors; doping, n-type, p type semiconductors, energy band diagrams; majority and minority charge carries; properties of p-n junction diode, forward bias and reverse bias diagrams and graphs; volt-ampere characteristics of p-n junction. Definitions of the following: break down voltage, knee voltage, maximum forward current, Peak inverse voltage (PIV), maximum power rating.

8. Power supply for electronic apparatus. Mains transformer. The diode; half wave, full wave and bridge rectifiers, voltage doubler. Filters; RC filters, chokes, bleeder resistance and its functions.

   Mains transformer; semiconductor diodes as half wave rectifier, full wave rectifier, bridge rectifier. Forward resistance, forward current, reverse current, derivation for: d.c (average current I_{dc}). Root mean square (rms) current (I_{rms}), efficiency of rectification (η); advantages, disadvantages and uses, ripple factors; simple numericals.

   Voltage doublers: Types of filters: RC filter, choke Input (I/P) filter, π-section filter. Input (I/P) and Output (O/P) graphs. Zener diode for voltage stabilisation, importance of series Resistor in the stabilization circuit, simple numericals. Chokes, bleeder resistors and their functions.

9. Vacuum triode. Structure of the vacuum triode valve. The control grid. Triode valve characteristics. Triode parameters; anode resistance, mutual conductance and amplification factors; relationship between the above parameters. Triode as a voltage amplifier. Bias voltage, cathode resistor and cathode bypass capacitor.

   Structure of the vacuum triode, control grid, triode value characteristics, grid cut off voltage. Plate characteristics, mutual characteristics; vacuum tube constants (Triode parameters), relationship between them, simple numericals. Triode as voltage amplifier: bias voltage, cathode resistor and cathode bypass capacitor; current in vacuum, causes of tube failure. Significance of vacuum in tubes.

10. Semiconductor Transistors. The junction transistor: PNP and NPN types. Introduction to various methods of construction; their characteristics including handling procedures and precautions.

    Self-explanatory.

11. Transistor amplifier. Introduction to the common-base, common emitter and common collector amplifiers. Comparison of the voltage, current and power gains and input and output resistances (elementary approach only). Phase relationship. Bias stabilization.

    Modes of connections: Common-Base (CB), Common-Emitter (CE), Common-Collector (CC) amplifiers: current amplification factors ($\propto$, β and γ) and their relationship. Simple numericals on the above.

    I/P and O/P characteristics, comparison of the voltage, current and power gain, I/P & O/P resistance (elementary approach only). Phase relationship, bias stabilization, single stage RC coupled amplifier circuit, bias circuit, emitter bypass capacitor, transistor current equation $\Delta I_E = \Delta I_B + \Delta I_C$. *Phase reversal in CE mode.*

12. The amplifier. A typical amplifier voltage and power amplification. Matching of the power output stage to a speaker.

    Voltage Amplifier (RC Coupled) circuit; Power amplifier circuit, impedance matching of the power (O/P) stage to the speaker; advantages, disadvantages, frequency responses (qualitative), Applications. Differences between transistors and tubes.

13. Apparatus for reproducing and recording sounds. Range of hearing, recording and reproducing.

    Characteristics of microphones; types of microphones: carbon, crystal, moving-coil and ribbon types. The common types of gramophone pick-ups. The earphone, crystal and magnetic tapes. The moving-coil loudspeakers; permanent magnet. Electrostatic speaker.

    Construction, working, advantages and disadvantages of the above.

14. Common types of electronic measuring instruments. Valve voltmeters, transistorized voltmeter, signal generator, oscilloscope, use and care of the above instruments.

    Simple circuit diagrams of the above instruments are expected.

    Valve voltmeters (VTVM), transistorized voltmeter, signal generator, oscilloscope (CRT); uses of Oscilloscope to measure: (a) the peak value of an 'ac' voltage; (b) the frequency of an electrical signal; (c) the time interval (can be used as a clock). Multimeter used as voltmeter, ohm-meter and ammeter.