

FUNDAMENTALS OF ELECTRICAL ENGINEERING

Diploma in electronics and Communication Engineering

Total questions: 150 (30 per unit, Units I to V)

Unit I: Electrical Fundamentals - 30 questions

Unit II: DC Circuits and Theorems - 30 questions

Unit III: AC Circuits - 30 questions

Unit IV: Electro Magnetic Circuit - 30 questions

Unit V: Batteries - 30 questions

UNIT-I: ELECTRICAL FUNDAMENTALS

Q1. What is electricity?

Answer: Electricity is a form of energy associated with the presence and movement of electric charges.

Q2. Define electric charge and state its SI unit.

Answer: Electric charge is a property of matter that causes electrical effects. Its SI unit is the coulomb (C).

Q3. What are free electrons?

Answer: Free electrons are electrons that can move relatively freely through a material and help conduct electric current.

Q4. Define electric current.

Answer: Electric current is the rate of flow of electric charge. Formula: $I = Q/t$. SI unit: ampere (A).

Q5. What is electric potential?

Answer: Electric potential is the work done per unit positive charge to bring it from a reference point to a given point. Unit: volt (V).

Q6. Define potential difference.

Answer: Potential difference is the work done per unit charge to move charge between two points. Formula: $V = W/Q$. Unit: volt (V).

Q7. Define electrical energy and give its formula.

Answer: Electrical energy is the electrical work done or energy transferred. For constant DC values, $E = VIt$. Unit: joule (J); commercial unit: kWh.

Q8. Define electrical power.

Answer: Electrical power is the rate of electrical energy transfer. $P = VI = I^2R = V^2/R$. Unit: watt (W).

Q9. Define resistance and state its unit.

Answer: Resistance is opposition to current flow. $R = V/I$. Its SI unit is ohm (Ω).

Q10. State Ohm's law.

Answer: At constant temperature and physical conditions, current is directly proportional to voltage: $V = IR$.

Q11. State two laws of resistance.

Answer: Resistance is directly proportional to conductor length and inversely proportional to its cross-sectional area.

Q12. Write the formula for resistance in terms of resistivity.

Answer: $R = \rho L/A$, where ρ is resistivity, L is length and A is cross-sectional area.

Q13. Define resistivity and state its unit.

Answer: Resistivity is a material property equal to the resistance of a specimen of unit length and unit area. Unit: $\Omega \cdot m$.

Q14. Define conductivity and state its unit.

Answer: Conductivity is the ability of a material to conduct current and is the reciprocal of resistivity: $\sigma = 1/\rho$. Unit: S/m .

Q15. How does temperature affect metallic resistance?

Answer: For most metals, resistance increases as temperature rises and decreases as temperature falls.

Q16. What is the temperature coefficient of resistance?

Answer: It is the fractional change in resistance per degree change in temperature. Formula: $\alpha = (R_T - R_0) / (R_0 (T - T_0))$

Unit: $^{\circ}C^{-1}$ or K^{-1} .

Q17. Name three types of resistors.

Answer: Fixed resistors, variable resistors and special resistors such as thermistors and LDRs.

Q18. What is a fixed resistor?

Answer: A fixed resistor has a resistance value that is not intended to be adjusted during normal use.

Q19. What is a variable resistor?

Answer: A variable resistor allows its resistance to be adjusted; examples include a potentiometer and rheostat.

Q20. What information does resistor colour coding provide?

Answer: Colour bands indicate the resistance digits, multiplier and tolerance; some resistors also indicate temperature coefficient.

Q21. What is an inductor?

Answer: An inductor is a component that stores energy in a magnetic field when current flows through it. Inductance is measured in henry (H).

Q22. What is the function of an inductor?

Answer: An inductor opposes changes in current and is used in filters, chokes, transformers and power supplies.

Q23. What is the wattage rating of a resistor?

Answer: It is the maximum power the resistor can safely dissipate under specified conditions, such as 0.25 W or 1 W.

Q24. Why is resistor wattage important?

Answer: A suitable rating prevents overheating and damage. The expected power should be below the rated limit with a safety margin.

Q25. What is a capacitor?

Answer: A capacitor stores electric charge and energy in an electric field. Capacitance is measured in farad (F).

Q26. Define capacitance.

Answer: Capacitance is charge stored per unit potential difference: $C = Q/V$. Unit: farad (F).

Q27. State two factors affecting capacitance.

Answer: Capacitance increases with plate area and dielectric permittivity, and decreases as plate separation increases.

Q28. How are capacitors combined in parallel?

Answer: The equivalent capacitance is the sum: $C_{eq} = C_1 + C_2 + C_3 + \dots$

Q29. How are capacitors combined in series?

Answer: The reciprocal equivalent capacitance is the sum of reciprocals:
 $1/C_{eq} = 1/C_1 + 1/C_2 + \dots$

Q30. What is the difference between an inductor and a capacitor?

Answer: An inductor stores energy in a magnetic field and opposes changes in current; a capacitor stores energy in an electric field and opposes changes in voltage.

UNIT-II: DC CIRCUITS AND THEOREMS

Q1. State Ohm's law.

Answer: At constant temperature and physical conditions, $V = IR$; voltage is proportional to current.

Q2. How is Ohm's law verified experimentally?

Answer: Connect an ammeter in series and a voltmeter across a resistor. Vary the supply and check that V/I remains approximately constant.

Q3. What is the V–I graph of an ohmic resistor?

Answer: It is a straight line through the origin; its slope on a V-versus-I graph equals resistance.

Q4. State Kirchhoff's Current Law (KCL).

Answer: The algebraic sum of currents at a node is zero; total current entering equals total current leaving.

Q5. State Kirchhoff's Voltage Law (KVL).

Answer: The algebraic sum of voltage rises and drops around a closed loop is zero.

Q6. What is a node?

Answer: A node is a junction or connected region where circuit elements share the same electrical potential.

Q7. What is the difference between KCL and KVL?

Answer: KCL follows conservation of charge at a junction; KVL follows conservation of energy around a closed loop.

Q8. What is a star connection?

Answer: In a star (Y) network, three resistors meet at one common point and their other ends form three terminals.

Q9. What is a delta connection?

Answer: In a delta (Δ) network, three resistors connect end-to-end to form a triangle with three terminals.

Q10. Give the delta-to-star formula for one star arm.

Answer: For delta sides R_{AB} , R_{BC} and R_{CA} , $R_A = (R_{AB} \times R_{CA}) / (R_{AB} + R_{BC} + R_{CA})$.

Q11. Give the star-to-delta formula for side R_{AB} .

Answer: For star arms R_A , R_B and R_C , $R_{AB} = (R_A R_B + R_B R_C + R_C R_A) / R_C$.

Q12. What is an ideal voltage source?

Answer: It maintains constant terminal voltage for any load current and has zero internal resistance.

Q13. What is a practical voltage source?

Answer: It is modelled as an ideal voltage source in series with internal resistance; terminal voltage generally falls as load current rises.

Q14. What is an ideal current source?

Answer: It supplies constant current regardless of terminal voltage and has infinite internal resistance.

Q15. What is a practical current source?

Answer: It is modelled as an ideal current source in parallel with a large but finite internal resistance.

Q16. Describe the ideal voltage-source characteristic.

Answer: Voltage remains constant as current changes; the V–I graph is a constant-voltage line.

Q17. Describe the ideal current-source characteristic.

Answer: Current remains constant as terminal voltage changes; the I–V graph is a constant-current line.

Q18. Define mesh analysis.

Answer: Mesh analysis assigns currents to independent meshes and applies KVL to find unknown currents.

Q19. What is a mesh?

Answer: A mesh is a loop in a planar circuit that contains no other loop inside it.

Q20. What is loop analysis?

Answer: Loop analysis applies KVL around selected closed paths to determine unknown circuit quantities; mesh analysis is a special case.

Q21. State Thevenin's theorem.

Answer: A linear bilateral two-terminal network can be replaced by an equivalent voltage source V_{th} in series with resistance R_{th} .

Q22. How is Thevenin voltage found?

Answer: Remove the load and calculate the open-circuit voltage across the output terminals; this is V_{th} .

Q23. How is Thevenin resistance found for independent sources?

Answer: Deactivate independent sources: short ideal voltage sources and open ideal current sources, then calculate resistance seen from the load terminals.

Q24. State Norton's theorem.

Answer: A linear bilateral two-terminal network can be replaced by a current source I_N in parallel with resistance R_N .

Q25. How is Norton current found?

Answer: Short the output terminals and calculate the short-circuit current; this is I_N .

Q26. State the relation between Thevenin and Norton equivalents.

Answer: $R^{th} = R_N$, $V^{th} = I_N R_N$ and $I_N = V^{th}/R^{th}$.

Q27. State the superposition theorem.

Answer: In a linear circuit, the total voltage or current is the algebraic sum of contributions from each independent source acting alone.

Q28. How are sources deactivated for superposition?

Answer: Replace an ideal voltage source with a short circuit and an ideal current source with an open circuit. Keep dependent sources active.

Q29. Can superposition be applied directly to power?

Answer: No. First find total voltage or current, then calculate power because power is nonlinear in voltage and current.

Q30. State the maximum power transfer theorem for a DC resistive circuit.

Answer: Maximum load power occurs when load resistance equals Thevenin resistance: $R_L = R^{th}$. Then $P_{max} = V^{th2}/(4R^{th})$.

UNIT-III: AC CIRCUITS

Q1. What is an AC cycle?

Answer: One complete set of positive and negative alternations of an alternating waveform is called a cycle.

Q2. Define frequency and state its unit.

Answer: Frequency is the number of cycles completed per second. Its SI unit is hertz (Hz).

Q3. Define time period.

Answer: Time period is the time taken to complete one cycle. $T = 1/f$, measured in seconds.

Q4. What is amplitude?

Answer: Amplitude is the maximum magnitude of an alternating quantity measured from its zero or mean reference.

Q5. Give one difference between AC and DC.

Answer: AC changes magnitude and periodically reverses direction; DC flows in one direction with constant or nearly constant polarity.

Q6. What is the instantaneous value of AC?

Answer: It is the value of an alternating quantity at a particular instant. For a sine wave, $v = V_m \sin(\omega t)$.

Q7. Define average value of a sinusoidal AC.

Answer: Over a complete cycle the average is zero; over one half-cycle the average value is $2V_m/\pi$, approximately $0.637V_m$.

Q8. Define RMS value.

Answer: RMS value is the equivalent DC value that produces the same heating effect in a resistor. For a sine wave, $V_{rms} = V_m/\sqrt{2}$.

Q9. What is the maximum value of a sinusoidal quantity?

Answer: It is the peak value, the largest magnitude reached during a cycle, denoted V_m or I_m .

Q10. Define form factor.

Answer: Form factor is RMS value divided by average rectified value. For a sine wave it is approximately 1.11.

Q11. Define peak factor.

Answer: Peak factor is maximum value divided by RMS value. For a sine wave it is $\sqrt{2}$, approximately 1.414.

Q12. What is conductance?

Answer: Conductance is the ease with which current flows and is the reciprocal of resistance: $G = 1/R$. Unit: siemens (S).

Q13. What is susceptance?

Answer: Susceptance is the imaginary part of admittance and indicates how readily a circuit permits reactive current. Unit: siemens (S).

Q14. Define admittance.

Answer: Admittance is the reciprocal of impedance: $Y = 1/Z$. It combines conductance and susceptance and is measured in siemens.

Q15. Define impedance.

Answer: Impedance is the total opposition to AC, combining resistance and reactance. Its unit is ohm (Ω).

Q16. What is inductive reactance?

Answer: Inductive reactance is an inductor's opposition to AC: $X_L = 2\pi fL$. It increases with frequency.

Q17. What is capacitive reactance?

Answer: Capacitive reactance is a capacitor's opposition to AC: $X_C = 1/(2\pi fC)$. It decreases as frequency increases.

Q18. What is a pure resistive AC circuit?

Answer: Voltage and current are in phase, and the power factor is 1.

Q19. What is a pure inductive AC circuit?

Answer: Current lags voltage by 90° in an ideal inductor; average power over a complete cycle is zero.

Q20. What is a pure capacitive AC circuit?

Answer: Current leads voltage by 90° in an ideal capacitor; average power over a complete cycle is zero.

Q21. What is an RL circuit?

Answer: An RL circuit contains resistance and inductance. In a series RL circuit, current lags the supply voltage by an angle determined by R and XL.

Q22. What is an RC circuit?

Answer: An RC circuit contains resistance and capacitance. In a series RC circuit, current leads the supply voltage by an angle determined by R and XC.

Q23. What is resonance in an RLC circuit?

Answer: Resonance occurs when inductive and capacitive reactances are equal: $X_L = X_C$.

Q24. Write the resonant frequency formula.

Answer: For an ideal RLC circuit, $f_r = 1/(2\pi\sqrt{LC})$.

Q25. What is series resonance?

Answer: In a series RLC circuit at resonance, impedance is minimum and equals R, current is maximum, and power factor is unity.

Q26. What is parallel resonance?

Answer: In a parallel resonant circuit, input impedance is ideally maximum and supply current is minimum at the resonant frequency.

Q27. What is real or active power?

Answer: Active power is the average power converted into useful work or heat. $P = VI \cos\phi$, measured in watts (W).

Q28. What is reactive power?

Answer: Reactive power is power exchanged between the source and reactive components. $Q = VI \sin\phi$, measured in var.

Q29. Define power factor.

Answer: Power factor is the ratio of active power to apparent power: $PF = P/S = \cos\phi$ for sinusoidal conditions.

Q30. Why is power factor important?

Answer: A higher power factor reduces current for a given real power, helping reduce losses and voltage drop and improving system capacity.

UNIT–IV: ELECTROMAGNETIC CIRCUIT

Q1. What is a magnetic field?

Answer: A magnetic field is the region in which a magnetic force can act on a magnet, moving charge or current-carrying conductor.

Q2. What produces a magnetic field around a conductor?

Answer: Electric current flowing through a conductor produces a magnetic field around it.

Q3. Define magnetomotive force (MMF).

Answer: MMF is the driving force that establishes magnetic flux in a magnetic circuit. $MMF = NI$, measured in ampere-turns.

Q4. Define magnetic flux.

Answer: Magnetic flux is the total magnetic field passing through a surface. Its SI unit is weber (Wb).

Q5. Define flux density.

Answer: Magnetic flux density is flux per unit area normal to the field: $B = \Phi/A$. Unit: tesla (T).

Q6. What is reluctance?

Answer: Reluctance is the opposition a magnetic circuit offers to magnetic flux. It is analogous to electrical resistance.

Q7. Write the formula for reluctance.

Answer: Reluctance $\mathfrak{R} = l/(\mu A)$, where l is magnetic path length, μ is permeability and A is cross-sectional area.

Q8. Define permeability.

Answer: Permeability indicates how easily a material supports magnetic flux. It is represented by μ and measured in H/m.

Q9. State the analogy between electric and magnetic circuits.

Answer: EMF corresponds to MMF, current to magnetic flux, and electrical resistance to magnetic reluctance.

Q10. State Faraday's law of electromagnetic induction.

Answer: The induced EMF is proportional to the rate of change of magnetic flux linkage: $e = -N(d\Phi/dt)$.

Q11. What does the negative sign in Faraday's law indicate?

Answer: It represents Lenz's law: induced EMF acts in a direction that opposes the change producing it.

Q12. State Lenz's law.

Answer: The direction of induced current is such that its magnetic effect opposes the change in magnetic flux that caused it.

Q13. What is electromagnetic induction?

Answer: It is the production of an EMF in a conductor or coil when the magnetic flux linked with it changes.

Q14. Define self-inductance.

Answer: Self-inductance is the property by which a changing current in a coil induces an EMF in the same coil. $e = -L(di/dt)$.

Q15. State the SI unit of inductance.

Answer: The SI unit is henry (H). One henry produces 1 V when current changes at 1 A/s.

Q16. Define mutual inductance.

Answer: Mutual inductance is the property by which changing current in one coil induces an EMF in a nearby coil. Unit: henry (H).

Q17. What is the difference between self and mutual induction?

Answer: Self-induction produces EMF in the same coil due to changing current; mutual induction produces EMF in another coupled coil.

Q18. What is coefficient of coupling?

Answer: It is the fraction of magnetic flux produced by one coil that links the other coil. It ranges from 0 to 1.

Q19. Write the relation between mutual inductance and coupling.

Answer: For two coils, $M = k\sqrt{L_1L_2}$, where k is the coefficient of coupling.

Q20. What is induced EMF?

Answer: Induced EMF is the voltage generated in a circuit by a change in linked magnetic flux.

Q21. What is the energy stored in an inductor?

Answer: The energy stored in an ideal inductor is $W = \frac{1}{2}LI^2$ joules.

Q22. How are inductors connected in series without mutual coupling?

Answer: Equivalent inductance is $L_{eq} = L_1 + L_2 + \dots$

Q23. How are inductors connected in parallel without mutual coupling?

Answer: For uncoupled inductors, $1/L_{eq} = 1/L_1 + 1/L_2 + \dots$

Q24. What happens when current through an inductor changes?

Answer: A self-induced EMF appears that opposes the change in current.

Q25. What is a magnetic circuit?

Answer: A magnetic circuit is a closed path followed by magnetic flux, usually through magnetic material and air gaps.

Q26. What is the magnetic equivalent of Ohm's law?

Answer: Hopkinson's law states $\Phi = \text{MMF}/\text{reluctance}$, analogous to $I = V/R$.

Q27. What is the effect of an air gap in a magnetic circuit?

Answer: An air gap greatly increases reluctance because air has much lower permeability than typical magnetic core materials.

Q28. What is hysteresis?

Answer: Hysteresis is the lag of magnetic flux density behind the magnetizing force as a magnetic material is cycled.

Q29. What are eddy currents?

Answer: Eddy currents are circulating currents induced within a conducting core by changing magnetic flux; they cause heating and losses.

Q30. How can eddy-current losses be reduced?

Answer: Use a laminated core made of thin, insulated sheets or use materials with higher electrical resistivity.

UNIT-V: BATTERIES

Q1. What is a battery?

Answer: A battery is one or more electrochemical cells that convert stored chemical energy into electrical energy.

Q2. What is a primary cell?

Answer: A primary cell is generally non-rechargeable because its chemical reaction is not readily reversible under normal use.

Q3. What is a secondary cell?

Answer: A secondary cell is rechargeable because its chemical reaction can be reversed by applying electrical energy.

Q4. Give two examples of primary batteries.

Answer: Zinc-carbon and alkaline batteries are common primary batteries.

Q5. Give two examples of secondary batteries.

Answer: Lead-acid and lithium-ion batteries are common rechargeable batteries.

Q6. What is a lead-acid battery?

Answer: It is a rechargeable battery using lead dioxide as the positive active material, lead as the negative active material and sulfuric acid as electrolyte.

Q7. What is the nominal voltage of one lead-acid cell?

Answer: One lead-acid cell has a nominal voltage of about 2 V.

Q8. What is the basic working principle of a lead-acid battery?

Answer: During discharge, chemical reactions convert stored chemical energy into electrical energy; charging reverses these reactions.

Q9. Name the main parts of a lead-acid battery.

Answer: Main parts include positive and negative plates, separators, electrolyte, container, terminals and vent or safety arrangements.

Q10. What is a nickel-cadmium battery?

Answer: It is a rechargeable alkaline battery using nickel-based positive material, cadmium negative material and potassium hydroxide electrolyte.

Q11. State one advantage of a nickel-cadmium battery.

Answer: It can deliver high current and tolerate many charge-discharge cycles when properly used.

Q12. State one limitation of a nickel-cadmium battery.

Answer: Cadmium is toxic, and the battery can suffer from memory-effect-related performance concerns under some usage conditions.

Q13. What is a lithium-ion battery?

Answer: It is a rechargeable battery in which lithium ions move between positive and negative electrodes during charge and discharge.

Q14. State two advantages of lithium-ion batteries.

Answer: They have high energy density and relatively low self-discharge compared with many older rechargeable chemistries.

Q15. Why does a battery need protection circuitry?

Answer: Protection helps prevent unsafe overcharge, over-discharge, excessive current and overheating, depending on battery chemistry.

Q16. What is battery capacity?

Answer: Battery capacity is the amount of charge a battery can deliver under specified conditions, commonly expressed in ampere-hours (Ah).

Q17. What does a 10 Ah battery rating mean?

Answer: It indicates a nominal charge capacity of 10 ampere-hours under the specified test conditions; actual runtime depends on load and conditions.

Q18. What is a battery's state of charge (SoC)?

Answer: SoC estimates the remaining charge in a battery as a percentage of its usable capacity.

Q19. What is battery maintenance?

Answer: Battery maintenance includes inspection, keeping terminals clean, ensuring correct charging and following the manufacturer's safety instructions.

Q20. How should a flooded lead-acid battery be maintained?

Answer: Check electrolyte level as directed, use only the recommended water when topping up, keep vents clear and avoid sparks or flames.

Q21. Why should battery terminals be kept clean?

Answer: Clean terminals reduce contact resistance, voltage drop, heating and unreliable connections.

Q22. What is a series connection of batteries?

Answer: In series, positive of one cell connects to negative of the next; voltages add while ampere-hour capacity is generally unchanged for matched cells.

Q23. What is a parallel connection of batteries?

Answer: In parallel, positive terminals are connected together and negative terminals together; voltage stays the same while capacity can increase for matched batteries.

Q24. State one precaution when connecting batteries in parallel.

Answer: Use compatible batteries of the same chemistry, voltage and similar condition, and follow manufacturer guidance to avoid large equalization currents.

Q25. What is battery disposal?

Answer: Battery disposal means sending used batteries to an appropriate collection or recycling system rather than putting them in ordinary waste.

Q26. Why should batteries not be burned or punctured?

Answer: They may release hazardous chemicals, catch fire, explode or cause injury.

Q27. What is a solar cell?

Answer: A solar cell is a semiconductor device that converts sunlight directly into electrical energy by the photovoltaic effect.

Q28. What is a solar panel?

Answer: A solar panel is an assembly of interconnected solar cells that produces useful electrical power.

Q29. Name two applications of solar cells.

Answer: Applications include calculators, rooftop electricity systems, streetlights, satellites and remote sensors.

Q30. State one advantage and one limitation of solar panels.

Answer: Advantage: they generate electricity without fuel during operation.

Limitation: output depends on sunlight and often requires storage or grid support.