DSSSB AE/JE 2026

COMPLETE
BASICS OF ELECTRICAL ENGINEERING NOTES

Complete Theory • Detailed Hinglish Explanation • Step-by-Step Derivations
Solved Examples • Engineering Applications • Practice Questions

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How to use this book: Read Complete Theory, reinforce it with the Hinglish Explanation, review every formula and derivation row, then attempt all twenty questions without viewing the solutions. Questions are original DSSSB-style practice, not claimed verbatim previous-year questions.

Electrical Engineering Units and Conventions

1. 1 A = 1 C/s
2. 1 V = 1 J/C
3. 1 ohm = 1 V/A
4. 1 W = 1 V A
5. 1 kW = 1000 W
6. 1 kWh = 3.6 x 10^6 J
7. use RMS values for AC power unless stated
8. declare passive sign convention and phase sequence.

How to Study This Book

Exam Method: Circuit Diagram, Polarity, Phasors and Unit Checks

Begin every electrical problem by drawing the circuit or phasor diagram and marking current directions, voltage polarities, terminals and reference node. State whether values are instantaneous, peak, RMS, DC or phasor quantities. Use the passive sign convention consistently and allow a negative result to indicate that the actual direction is opposite to the assumption.

For networks, apply KCL at nodes and KVL around loops without changing sign conventions midway. For AC circuits, convert quantities to a common rectangular or polar form before addition, and distinguish active, reactive and apparent power. For transformers and machines, identify motor or generator operation before selecting the voltage equation.

For instruments, verify series or parallel connection and safe range before energizing. Check dimensions, units, phase sequence, line-versus-phase quantities and limiting cases. In MCQs, eliminate options using physical behaviour: an inductor opposes current change, a capacitor opposes voltage change, a transformer needs alternating flux, and an induction rotor requires nonzero slip.

Maintain an error log for source deactivation, leading-lagging signs, star-delta factors, machine rules and instrument connections.

CHAPTER 1 — FUNDAMENTALS OF ELECTRIC CIRCUITS AND NETWORK THEOREMS

1. Introduction

Circuit theory provides a disciplined way to calculate currents, voltages, power and energy in interconnected sources and elements. The chapter develops sign conventions, systematic mesh and nodal methods, network conversion and equivalent-source theorems used in wiring, controls and electronic interfaces.

2. Complete Theory

Electrical quantities, sources and elements

Charge Q is the basic electrical quantity; current $I=dQ/dt$ is charge-flow rate and voltage is energy transferred per unit charge. Passive sign convention makes absorbed power $P=VI$ positive when current enters the positive-voltage terminal.

Resistance obeys $V=IR$ for an ohmic element. Sources may be independent or controlled; practical voltage sources include series resistance and practical current sources parallel resistance.

Hinglish Explanation

Suppose ek battery resistor ko supply kar rahi hai. Current ki direction aur voltage polarity pehle mark karo.

Current positive terminal mein enter kare to VI absorbed power hai; source ke liye calculated power negative aa sakti hai, matlab source deliver kar raha hai.

Series, parallel, KCL and KVL

Series elements carry common current and parallel elements share voltage. KCL states algebraic current sum at a node is zero because charge does not accumulate in a lumped ideal node.

KVL states algebraic voltage sum around a closed loop is zero from energy conservation. Sign consistency is more important than guessed current direction.

Hinglish Explanation

Junction ko traffic circle samjho: jitna current enter kare utna leave kare. Loop mein voltage rise aur drops ka signed sum zero.

Assumed direction wrong ho to answer negative aayega, physics wrong nahi.

Mesh, nodal and network conversion

Mesh analysis writes KVL in independent planar loops; nodal analysis writes KCL at nonreference nodes. Supermesh handles a current source common to meshes and supernode encloses a voltage source between unknown nodes.

Δ-star conversion replaces a three-terminal network without changing terminal behaviour.

Hinglish Explanation

Voltage sources wale circuits mein mesh often simple, current sources mein nodal.

Supermesh ya supernode source ko ignore nahi karta; source constraint separate equation deta hai.

Thevenin, Norton, superposition and maximum power

A linear two-terminal network becomes V_{th} in series with R_{th} or I_N in parallel with R_N, where $R_N=R_{th}$ and $I_N=V_{th}/R_{th}$. Deactivate independent voltage sources by shorting and current sources by opening; dependent sources remain active.

Superposition applies to voltages/currents, not directly to power. For a resistive DC load, maximum power occurs at $R_L=R_{th}$.

Hinglish Explanation

Load baar-baar change ho to poora network solve karne ke badle Thevenin equivalent use karo. Dependent source ko off karna common exam trap hai; usko active rakho.

4. Engineering Formula Section

Formula Sheet
1. $I=Q/t$
2. $V=W/Q$
3. $R=\rho\ l/A$
4. $G=1/R$
5. $P=VI=I^{2R}=V^2/R$
6. energy $E=Pt$
7. sum $I=0$
8. sum $V=0$
9. voltage divider $V_k=V\ R_k/\text{sum } R$
10. current divider $I_k=I\ G_k/\text{sum } G$
11. R_{delta}-to-star at node a$=R_{abRca}/(R_{ab}+R_{bc}+R_{ca})$
12. $V_{th}=V_{oc}$
13. $I_N=I_{sc}$
14. $R_{th}=V_{th}/I_N$
15. $P_L=V_{th}{}^{2R}{}_L/(R_{th}+R_L)^2$
16. at maximum power $R_L=R_{th}$

5. Formula Derivations and Solved Examples

KCL follows by integrating charge conservation over a node. KVL follows because electrostatic potential is single-valued in a lumped circuit. For maximum power, differentiate $P_L=V_{th}$ squared times R_L divided by $(R_{th}+R_L)$ squared; setting the derivative to zero gives $R_L=R_{th}$. Example: $V_{th}=12$ V,$R_{th}=4$ ohm gives maximum load power 9 W.

6. Practical Applications

• Domestic circuits, sensor interfaces, control panels, battery systems and troubleshooting.

7. Short Tricks

• Choose a reference node first.

• Negative current means opposite to assumption.

• Voltage source off means short; current source off means open.

8. Concept Diagram

```
THEVENIN / NORTON
Network -> [Vth]--Rth--Load
Equivalent: [In] in parallel with Rth and Load
In=Vth/Rth
```

9. Comparison Table

Method	Primary law	Best suited
Mesh	KVL	few planar loops
Nodal	KCL	few nodes
Thevenin	two-terminal equivalent	changing load
Superposition	one independent source at a time	linear response

10. Common Mistakes

• Adding voltages without polarity.

• Turning off dependent sources.

• Applying superposition directly to power.

• Using maximum-power condition as maximum-efficiency condition.

11. Important DSSSB Exam Points

• KCL/KVL signs, source deactivation and Thevenin-Norton conversion are high-yield.

12. Chapter Revision Sheet

Define directions and polarities before equations. Use nodal or mesh systematically, then verify power balance.

13. Practice Questions with Solutions

Attempt each question first. The explanation discusses only the correct answer.

Q1. KCL expresses

(A) charge conservation
(B) energy conservation around a loop
(C) open-circuit terminal voltage
(D) short-circuit terminal current

Correct Answer: (A)
Algebraic node current is zero.

Q2. KVL expresses

(A) open-circuit terminal voltage
(B) energy conservation around a loop
(C) short-circuit terminal current
(D) $R_L = R_{th}$

Correct Answer: (B)
Voltage rises and drops sum to zero.

Q3. Thevenin voltage is

(A) short-circuit terminal current
(B) $R_L = R_{th}$
(C) open-circuit terminal voltage
(D) charge conservation

Correct Answer: (C)
It is V_{oc}.

Q4. Norton current is

(A) $R_L = R_{th}$
(B) charge conservation
(C) energy conservation around a loop
(D) short-circuit terminal current

Correct Answer: (D)
It is I_{sc}.

Q5. Maximum resistive load power occurs at

(A) $R_L = R_{th}$
(B) charge conservation
(C) energy conservation around a loop
(D) open-circuit terminal voltage

Correct Answer: (A)
Differentiate load power.

Q6. Select the correct result: KCL expresses

(A) energy conservation around a loop
(B) charge conservation
(C) open-circuit terminal voltage
(D) short-circuit terminal current

Correct Answer: (B)
Algebraic node current is zero.

Q7. Select the correct result: KVL expresses

(A) open-circuit terminal voltage
(B) short-circuit terminal current
(C) energy conservation around a loop
(D) $R_L=R_{th}$

Correct Answer: (C)
Voltage rises and drops sum to zero.

Q8. Select the correct result: Thevenin voltage is

(A) short-circuit terminal current
(B) $R_L=R_{th}$
(C) charge conservation
(D) open-circuit terminal voltage

Correct Answer: (D)
It is V_{oc}.

Q9. Select the correct result: Norton current is

(A) short-circuit terminal current
(B) $R_L=R_{th}$
(C) charge conservation
(D) energy conservation around a loop

Correct Answer: (A)
It is I_{sc}.

Q10. Select the correct result: Maximum resistive load power occurs at

(A) charge conservation
(B) $R_L=R_{th}$
(C) energy conservation around a loop
(D) open-circuit terminal voltage

Correct Answer: (B)
Differentiate load power.

Q11. Under the standard assumptions, KCL expresses

(A) energy conservation around a loop
(B) open-circuit terminal voltage
(C) charge conservation
(D) short-circuit terminal current

Correct Answer: (C)
Algebraic node current is zero.

Q12. Under the standard assumptions, KVL expresses

(A) open-circuit terminal voltage
(B) short-circuit terminal current
(C) $R_L=R_{th}$
(D) energy conservation around a loop

Correct Answer: (D)
Voltage rises and drops sum to zero.

Q13. Under the standard assumptions, Thevenin voltage is

(A) open-circuit terminal voltage
(B) short-circuit terminal current
(C) $R_L=R_{th}$
(D) charge conservation

Correct Answer: (A)

It is V_{oc}.

Q14. Under the standard assumptions, Norton current is

(A) $R_L=R_{th}$
(B) short-circuit terminal current
(C) charge conservation
(D) energy conservation around a loop

Correct Answer: (B)

It is I_{sc}.

Q15. Under the standard assumptions, Maximum resistive load power occurs at

(A) charge conservation
(B) energy conservation around a loop
(C) $R_L=R_{th}$
(D) open-circuit terminal voltage

Correct Answer: (C)

Differentiate load power.

Q16. Which exam-ready statement completes: KCL expresses

(A) energy conservation around a loop
(B) open-circuit terminal voltage
(C) short-circuit terminal current
(D) charge conservation

Correct Answer: (D)

Algebraic node current is zero.

Q17. Which exam-ready statement completes: KVL expresses

(A) energy conservation around a loop
(B) open-circuit terminal voltage
(C) short-circuit terminal current
(D) $R_L=R_{th}$

Correct Answer: (A)

Voltage rises and drops sum to zero.

Q18. Which exam-ready statement completes: Thevenin voltage is

(A) short-circuit terminal current
(B) open-circuit terminal voltage
(C) $R_L=R_{th}$
(D) charge conservation

Correct Answer: (B)

It is V_{oc}.

Q19. Which exam-ready statement completes: Norton current is

(A) $R_L=R_{th}$
(B) charge conservation
(C) short-circuit terminal current
(D) energy conservation around a loop

Correct Answer: (C)

It is I_{sc}.

Q20. Which exam-ready statement completes: Maximum resistive load power occurs at

(A) charge conservation
(B) energy conservation around a loop
(C) open-circuit terminal voltage
(D) $R_L=R_{th}$

Correct Answer: (D)

Differentiate load power.

Quick Revision: Re-read the formula box, cover the answers, and explain each exam point aloud. A formula is ready for the exam only when its symbols, SI units, assumptions and sign convention are clear.

CHAPTER 2 — SINGLE-PHASE AND BALANCED THREE-PHASE AC CIRCUITS

1. Introduction

AC analysis uses sinusoidal waveforms and phasors to represent magnitude and phase compactly. Impedance, complex power, resonance and three-phase relationships support power distribution, motors, lighting, HVAC and industrial loads.

2. Complete Theory

Sinusoids, RMS and phasors

A sinusoid $v=V_m$ sin(omega t+phi) is described by peak, frequency and phase. RMS is the DC-equivalent heating value: V_{rms}=√[(1/T)integral v^{2dt}]=V_m/√2 for a sine wave.

A phasor suppresses common time variation and uses complex algebra; multiplication by j rotates a vector +90 degrees.

Hinglish Explanation

RMS average voltage nahi hai; heating-equivalent value hai. Phasor waveform ko freeze karke magnitude-angle vector banata hai.

j multiplication anticlockwise 90 degree rotation hai.

R, L, C and impedance

For a resistor voltage and current are in phase. In an inductor voltage leads current by 90 degrees and Z_L=j omega L.

In a capacitor current leads voltage by 90 degrees and Z_C=1/(j omega C)=-j/(omega C). Series impedances add; parallel analysis often uses admittance Y=1/Z.

Hinglish Explanation

Memory trick: ELI the ICE man - L mein E/V leads I, C mein I leads E/V. Sign of j reactance se phasor direction confirm karo.

Power, power factor and correction

Complex power S=VI* =P+jQ. P=VI cos phi is active power, Q=VI sin phi reactive power and |S|=VI apparent power.

Inductive loads lag and draw positive reactive power under the usual convention. Capacitors supply leading reactive power, reducing source current and losses.

Required capacitor kVAR is P(tan phi_1-tan phi_2).

Hinglish Explanation

Poor power factor mein same kW ke liye current zyada, so copper loss aur voltage drop zyada. Capacitor local reactive demand supply karke line current reduce karta hai.

Resonance and three-phase systems

Series resonance occurs when $X_L=X_C$, giving minimum impedance R, maximum current and unity power factor; f_r=1/(2π √(LC)). Balanced three-phase star has V_L=√3 V_{ph} and $I_L=I_{ph}$; delta has $V_L=V_{ph}$ and I_L=√3 I_{ph}.

Total power is √3 V_L I_L cos phi.

Hinglish Explanation

Resonance par L aur C ke reactive effects cancel hote hain. Star mein line voltage root-3 times phase, delta mein line current root-3 times phase - yeh pair exam mein frequently swap hota hai.

4. Engineering Formula Section

Formula Sheet
1. omega=2π f
2. $V_{rms}=V_m/\sqrt{2}$
3. form factor=V_{rms}/V_{avg}
4. peak factor=V_m/V_{rms}
5. $Z_R=R$
6. Z_L=j omega L
7. Z_C=1/(j omega C)
8. Y=1/Z
9. S=VI*=P+jQ
10. P=VI cos phi
11. Q=VI sin phi
12. capacitor VAR=P(tan phi_1-tan phi_2)
13. $f_r=1/(2\pi\sqrt{(LC)})$
14. $Q_{factor}=omega_{rL}/R$
15. bandwidth=f_r/Q
16. star $V_L=\sqrt{3}V_{ph}, I_L=I_{ph}$
17. delta $V_L=V_{ph}, I_L=\sqrt{3}I_{ph}$
18. $P_{3phase}=\sqrt{3}V_{LILcos}$ phi

5. Formula Derivations and Solved Examples

RMS derivation squares the sine, integrates over one cycle and takes the square root, giving $V_m/\sqrt{2}$. Series resonance follows imaginary part of Z=R+j(omega L-1/omega C) equal to zero. Star line voltage is the phasor difference of two 120-degree phase voltages, whose magnitude is √3 times phase voltage.

6. Practical Applications

• Motors, transformers, power-factor panels, three-phase distribution and resonance filters.

7. Short Tricks

• Use complex conjugate in S=VI*.

• Series resonance: Z minimum.

• PF correction changes Q, not useful kW load.

8. Concept Diagram

```
POWER TRIANGLE
      Q (VAR)
      |\ S (VA)
      | \ phi
      +---> P (W)
cos phi=P/S
```

9. Comparison Table

Circuit	Phase relation	Power
Pure R	V and I in phase	P only
Pure L	I lags 90 deg	+Q
Pure C	I leads 90 deg	-Q
Series resonance	unity PF	maximum current

10. Common Mistakes

• Using peak instead of RMS in power.

• Confusing leading and lagging.

• Swapping star/delta line relations.

• Adding phasor magnitudes arithmetically.

11. Important DSSSB Exam Points

• RMS, impedance, complex power, resonance and three-phase relations are central.

12. Chapter Revision Sheet

Convert to RMS phasors, construct impedance, solve current, then compute complex power and check phase sense.

13. Practice Questions with Solutions

Attempt each question first. The explanation discusses only the correct answer.

Q1. Sinusoidal RMS is

(A) peak divided by √2
(B) omega L
(C) leads voltage
(D) unity power factor

Correct Answer: (A)
Heating-equivalent result.

Q2. Inductive reactance is

(A) leads voltage
(B) omega L
(C) unity power factor
(D) √3 V_L I_L cos phi

Correct Answer: (B)
Z_L=j omega L.

Q3. Capacitor current

(A) unity power factor
(B) √3 V_L I_L cos phi
(C) leads voltage
(D) peak divided by √2

Correct Answer: (C)
Capacitive phase relation.

Q4. Series resonance has

(A) √3 V_L I_L cos phi
(B) peak divided by √2
(C) omega L
(D) unity power factor

Correct Answer: (D)
Reactances cancel.

Q5. Balanced three-phase power is

(A) √3 V_L I_L cos phi
(B) peak divided by √2
(C) omega L
(D) leads voltage

Correct Answer: (A)
Standard line-value formula.

Q6. Select the correct result: Sinusoidal RMS is

(A) omega L
(B) peak divided by √2
(C) leads voltage
(D) unity power factor

Correct Answer: (B)
Heating-equivalent result.

Q7. Select the correct result: Inductive reactance is

(A) leads voltage
(B) unity power factor
(C) omega L
(D) √3 V_L I_L cos phi

Correct Answer: (C)

Z_L=j omega L.

Q8. Select the correct result: Capacitor current

(A) unity power factor
(B) √3 V_L I_L cos phi
(C) peak divided by √2
(D) leads voltage

Correct Answer: (D)

Capacitive phase relation.

Q9. Select the correct result: Series resonance has

(A) unity power factor
(B) √3 V_L I_L cos phi
(C) peak divided by √2
(D) omega L

Correct Answer: (A)

Reactances cancel.

Q10. Select the correct result: Balanced three-phase power is

(A) peak divided by √2
(B) √3 V_L I_L cos phi
(C) omega L
(D) leads voltage

Correct Answer: (B)

Standard line-value formula.

Q11. Under the standard assumptions, Sinusoidal RMS is

(A) omega L
(B) leads voltage
(C) peak divided by √2
(D) unity power factor

Correct Answer: (C)

Heating-equivalent result.

Q12. Under the standard assumptions, Inductive reactance is

(A) leads voltage
(B) unity power factor
(C) √3 V_L I_L cos phi
(D) omega L

Correct Answer: (D)

Z_L=j omega L.

Q13. Under the standard assumptions, Capacitor current

(A) leads voltage
(B) unity power factor
(C) √3 V_L I_L cos phi
(D) peak divided by √2

Correct Answer: (A)
Capacitive phase relation.

Q14. Under the standard assumptions, Series resonance has

(A) √3 V_L I_L cos phi
(B) unity power factor
(C) peak divided by √2
(D) omega L

Correct Answer: (B)
Reactances cancel.

Q15. Under the standard assumptions, Balanced three-phase power is

(A) peak divided by √2
(B) omega L
(C) √3 V_L I_L cos phi
(D) leads voltage

Correct Answer: (C)
Standard line-value formula.

Q16. Which exam-ready statement completes: Sinusoidal RMS is

(A) omega L
(B) leads voltage
(C) unity power factor
(D) peak divided by √2

Correct Answer: (D)
Heating-equivalent result.

Q17. Which exam-ready statement completes: Inductive reactance is

(A) omega L
(B) leads voltage
(C) unity power factor
(D) √3 V_L I_L cos phi

Correct Answer: (A)
Z_L=j omega L.

Q18. Which exam-ready statement completes: Capacitor current

(A) unity power factor
(B) leads voltage
(C) √3 V_L I_L cos phi
(D) peak divided by √2

Correct Answer: (B)
Capacitive phase relation.

Q19. Which exam-ready statement completes: Series resonance has

(A) √3 V_L I_L cos phi
(B) peak divided by √2
(C) unity power factor
(D) omega L

Correct Answer: (C)
Reactances cancel.

Q20. Which exam-ready statement completes: Balanced three-phase power is

(A) peak divided by √2
(B) omega L
(C) leads voltage
(D) √3 V_L I_L cos phi

Correct Answer: (D)
Standard line-value formula.

Quick Revision: Re-read the formula box, cover the answers, and explain each exam point aloud. A formula is ready for the exam only when its symbols, SI units, assumptions and sign convention are clear.

CHAPTER 3 — MAGNETIC CIRCUITS, RELAYS AND TRANSFORMERS

1. Introduction

Magnetic circuits guide flux through cores and air gaps. Transformers use mutual induction to transfer AC power between voltage levels, while relays use magnetic force for switching and protection.

2. Complete Theory

Magnetic quantities and circuits

MMF NI drives flux Phi through reluctance R_m=l/(μ A), analogous to voltage driving current. Flux density B=Phi/A and field intensity H=NI/l.

The analogy is useful but imperfect because permeability is nonlinear, leakage exists and magnetic energy behaviour differs from resistive dissipation.

Hinglish Explanation
Electric circuit mein voltage current drive karta hai; magnetic circuit mein NI flux drive karta hai. Air gap ki permeability low hone se most MMF gap consume karta hai.

B-H curve and magnetic losses

The B-H curve shows permeability, saturation and hysteresis. Retentivity is residual flux density and coercivity is reverse H needed to demagnetize.

Hysteresis loss is proportional to loop area, frequency and core volume; eddy currents are reduced by thin insulated laminations and high-resistivity materials.

Hinglish Explanation
Core ko repeatedly magnetize karne par domain reversal energy consume karta hai. Laminations circulating eddy-current path ko tod kar loss reduce karti hain.

Transformer principle and EMF equation

An AC primary current creates alternating mutual flux linking both windings. Faraday law gives instantaneous emf N dPhi/dt; for sinusoidal flux RMS E=4.44 f N Phi_m.

Ideally $V_1/V_2=N_1/N_2$ and $I_1/I_2=N_2/N_1$. Rating is kVA because copper loss depends current and core loss mainly voltage/frequency, not load power factor.

Hinglish Explanation
Transformer frequency change nahi karta; voltage-current level trade karta hai. 4.44 sine-wave flux ke RMS derivation se aata hai.

Equivalent circuit, tests and performance

Winding resistance models copper loss, leakage reactance leakage flux, and shunt branch core loss plus magnetizing current. OC test mainly determines core-loss/shunt parameters; SC test determines equivalent series impedance and full-load copper loss at rated current.

Regulation measures secondary voltage change; maximum efficiency occurs when copper loss equals core loss.

Hinglish Explanation
OC test low current so copper loss negligible; SC test low voltage so core loss negligible. Test purpose swap karna common trap hai.

Autotransformer copper-efficient hai but electrical isolation nahi deta.

4. Engineering Formula Section

Formula Sheet
1. $Phi=F/R_m$
2. $F=NI$
3. $R_m=l/(\mu A)$
4. $B=Phi/A$
5. $H=NI/l$
6. $E=4.44fNPhi_m$
7. $V_1/V_2=N_1/N_2=k$
8. $I_1/I_2=N_2/N_1$
9. regulation=(V_{no}-load-V_{full}-load)/V_{full}-load x100
10. eta=output/(output+losses)
11. maximum eta when copper loss=core loss

5. Formula Derivations and Solved Examples

Let Phi=Phi_m sin omega t. Induced emf e=N omega Phi_m cos omega t, so peak emf is 2π f N Phi_m. RMS divides by √2, giving 4.44 f N Phi_m. Maximum-efficiency condition follows differentiating efficiency with load: variable copper loss equals constant core loss.

6. Practical Applications

- Power distribution, isolation, instrument transformers, relays and control panels.

7. Short Tricks

- OC gives core loss.
- SC gives copper loss/series impedance.
- Maximum efficiency: copper loss=core loss.

8. Concept Diagram

```
TRANSFORMER
AC V1 -> [N1 || magnetic core || N2] -> AC V2
mutual flux Phi links both windings
```

9. Comparison Table

Feature	Transformer	Autotransformer
Windings	electrically separate	common portion
Isolation	yes	no
Copper use	more	less
Use	general voltage conversion	close ratios where isolation unnecessary

10. Common Mistakes

- Using DC on a transformer.
- Reversing OC and SC test purposes.
- Rating transformer in kW.
- Ignoring air-gap reluctance.

11. Important DSSSB Exam Points

- EMF equation, ratings, tests, regulation and losses are frequent.

12. Chapter Revision Sheet

Build magnetic circuits with MMF, reluctance and flux. For transformers derive emf from sinusoidal flux and separate constant core loss from variable copper loss.

13. Practice Questions with Solutions

Attempt each question first. The explanation discusses only the correct answer.

Q1. Magnetic reluctance is

(A) l/(μ A)
(B) 4.44 f N Phi_m
(C) core loss and shunt parameters
(D) series impedance and copper loss

Correct Answer: (A)
Magnetic-circuit opposition.

Q2. Transformer EMF is

(A) core loss and shunt parameters
(B) 4.44 f N Phi_m
(C) series impedance and copper loss
(D) kVA

Correct Answer: (B)
Sinusoidal RMS equation.

Q3. OC test determines

(A) series impedance and copper loss
(B) kVA
(C) core loss and shunt parameters
(D) l/(μ A)

Correct Answer: (C)
Current is small.

Q4. SC test determines

(A) kVA
(B) I/(μ A)
(C) 4.44 f N Phi_m
(D) series impedance and copper loss

Correct Answer: (D)
Applied voltage is low.

Q5. Transformer rating is

(A) kVA
(B) I/(μ A)
(C) 4.44 f N Phi_m
(D) core loss and shunt parameters

Correct Answer: (A)
Losses depend primarily on voltage and current.

Q6. Select the correct result: Magnetic reluctance is

(A) 4.44 f N Phi_m
(B) I/(μ A)
(C) core loss and shunt parameters
(D) series impedance and copper loss

Correct Answer: (B)
Magnetic-circuit opposition.

Q7. Select the correct result: Transformer EMF is

(A) core loss and shunt parameters
(B) series impedance and copper loss
(C) 4.44 f N Phi_m
(D) kVA

Correct Answer: (C)
Sinusoidal RMS equation.

Q8. Select the correct result: OC test determines

(A) series impedance and copper loss
(B) kVA
(C) I/(μ A)
(D) core loss and shunt parameters

Correct Answer: (D)
Current is small.

Q9. Select the correct result: SC test determines

(A) series impedance and copper loss
(B) kVA
(C) I/(μ A)
(D) 4.44 f N Phi_m

Correct Answer: (A)
Applied voltage is low.

Q10. Select the correct result: Transformer rating is

(A) l/(μ A)
(B) kVA
(C) 4.44 f N Phi_m
(D) core loss and shunt parameters

Correct Answer: (B)
Losses depend primarily on voltage and current.

Q11. Under the standard assumptions, Magnetic reluctance is

(A) 4.44 f N Phi_m
(B) core loss and shunt parameters
(C) l/(μ A)
(D) series impedance and copper loss

Correct Answer: (C)
Magnetic-circuit opposition.

Q12. Under the standard assumptions, Transformer EMF is

(A) core loss and shunt parameters
(B) series impedance and copper loss
(C) kVA
(D) 4.44 f N Phi_m

Correct Answer: (D)
Sinusoidal RMS equation.

Q13. Under the standard assumptions, OC test determines

(A) core loss and shunt parameters
(B) series impedance and copper loss
(C) kVA
(D) l/(μ A)

Correct Answer: (A)
Current is small.

Q14. Under the standard assumptions, SC test determines

(A) kVA
(B) series impedance and copper loss
(C) l/(μ A)
(D) 4.44 f N Phi_m

Correct Answer: (B)
Applied voltage is low.

Q15. Under the standard assumptions, Transformer rating is

(A) l/(μ A)
(B) 4.44 f N Phi_m
(C) kVA
(D) core loss and shunt parameters

Correct Answer: (C)
Losses depend primarily on voltage and current.

Q16. Which exam-ready statement completes: Magnetic reluctance is

(A) 4.44 f N Phi_m
(B) core loss and shunt parameters
(C) series impedance and copper loss
(D) l/(μ A)

Correct Answer: (D)
Magnetic-circuit opposition.

Q17. Which exam-ready statement completes: Transformer EMF is

(A) 4.44 f N Phi_m
(B) core loss and shunt parameters
(C) series impedance and copper loss
(D) kVA

Correct Answer: (A)
Sinusoidal RMS equation.

Q18. Which exam-ready statement completes: OC test determines

(A) series impedance and copper loss
(B) core loss and shunt parameters
(C) kVA
(D) l/(μ A)

Correct Answer: (B)
Current is small.

Q19. Which exam-ready statement completes: SC test determines

(A) kVA
(B) l/(μ A)
(C) series impedance and copper loss
(D) 4.44 f N Phi_m

Correct Answer: (C)
Applied voltage is low.

Q20. Which exam-ready statement completes: Transformer rating is

(A) l/(μ A)
(B) 4.44 f N Phi_m
(C) core loss and shunt parameters
(D) kVA

Correct Answer: (D)
Losses depend primarily on voltage and current.

Quick Revision: Re-read the formula box, cover the answers, and explain each exam point aloud. A formula is ready for the exam only when its symbols, SI units, assumptions and sign convention are clear.

CHAPTER 4 — DC MACHINES, INDUCTION MOTORS AND SYNCHRONOUS MACHINES

1. Introduction

Electrical machines convert energy through electromagnetic induction and force. Construction, EMF, torque, speed, starting and characteristic relations determine applications in pumps, lifts, fans, drives and power generation.

2. Complete Theory

DC machine construction and generator action

The yoke supports poles and carries flux; field windings create stationary flux; armature conductors rotate; commutator mechanically rectifies internally alternating armature emf to DC at brushes. Generator EMF E_g=P Phi Z N/(60A), with A parallel paths determined by lap or wave winding.

Hinglish Explanation

Same hardware motor ya generator ban sakta hai. Generator mein mechanical input se emf/current output; commutator external DC maintain karta hai.

DC motor, torque and characteristics

Motor current in magnetic flux experiences force. Back emf E_b opposes supply and limits current: V=E_b+I_{aRa}.

Developed torque is proportional to Phi I_a, and speed approximately proportional to (V-I_{aRa})/Phi. A series motor has very high starting torque and must not run unloaded; a shunt motor has nearly constant speed.

Hinglish Explanation

Start par E_b zero, so direct current bahut high. Starter resistance current limit karti hai.

Series motor no-load par flux/current low hone se dangerous overspeed kar sakta hai.

Speed control and starters

Flux weakening raises speed; armature resistance control lowers speed but wastes power; voltage control offers efficient range with suitable supply. Three-point starter provides starting resistance, no-volt release and overload protection, but its no-volt coil is in series with shunt field.

Four-point starter separates that coil, avoiding nuisance release during field weakening.

Hinglish Explanation

3-point starter mein field current reduce karoge to hold coil weak ho sakti hai. 4-point coil supply ke across independent hoti hai.

Induction and synchronous machines

A balanced three-phase stator creates rotating field at N_s=120f/P. Induction rotor must have slip s=(N_s-N)/N_s for induced emf and torque; rotor frequency f_r=sf.

Alternator frequency is f=PN/120. A synchronous motor locks to rotating field at synchronous speed and is not inherently self-starting.

Hinglish Explanation

Induction rotor N_s reach kare to relative motion zero, rotor emf/torque zero, isliye it always slightly below synchronous speed. Synchronous motor once locked constant speed par chalta hai.

4. Engineering Formula Section

Formula Sheet

1. E_g=P Phi ZN/(60A)
2. E_b=V-I_{aRa}
3. T proportional to Phi I_a
4. N proportional to (V-I_{aRa})/Phi
5. N_s=120f/P
6. slip s=(N_s-N)/N_s
7. f_r=sf
8. alternator frequency f=PN/120

5. Formula Derivations and Solved Examples

DC generator emf follows average emf per conductor multiplied by series conductors per parallel path. Motor torque follows electromagnetic power E_{bIa} divided by mechanical angular speed, yielding T proportional to Phi I_a. Synchronous speed comes from one electrical cycle advancing one pole pair, giving 120f/P rpm.

6. Practical Applications

• Pumps, cranes, lifts, fans, conveyors, alternators and industrial drives.

7. Short Tricks

• Generator: right-hand rule.

• Motor: left-hand rule.

• At DC motor start E_b=0.

• Rotor frequency=slip times supply frequency.

8. Concept Diagram

```
DC MOTOR VOLTAGE
V -> R_a drop I_aR_a + opposing back emf E_b
At start E_b=0, so starter resistance is required.
```

9. Comparison Table

Machine	Speed nature	Typical feature
DC shunt motor	nearly constant	easy speed control
DC series motor	load dependent	high starting torque
Induction motor	below synchronous	rugged/self-starting
Synchronous motor	exact synchronous	not inherently self-starting

10. Common Mistakes

• Using generator and motor voltage equations interchangeably.

• Running series motor unloaded.

• Assuming induction rotor reaches synchronous speed.

• Confusing Fleming left and right rules.

11. Important DSSSB Exam Points

• EMF, torque, starter and slip equations are high-yield.

12. Chapter Revision Sheet

Connect physical construction to induction and force. Use back emf for motors, generated emf for generators, and slip for induction machines.

13. Practice Questions with Solutions

Attempt each question first. The explanation discusses only the correct answer.

Q1. DC generator emf is

(A) P Phi ZN/(60A)
(B) V-I_{aRa}
(C) Phi I_a
(D) 120f/P

Correct Answer: (A)
Standard equation.

Q2. DC motor back emf is

(A) Phi I_a
(B) V-I_{aRa}
(C) 120f/P
(D) sf

Correct Answer: (B)
Motor voltage balance.

Q3. DC torque is proportional to

(A) 120f/P
(B) sf
(C) Phi I_a
(D) P Phi ZN/(60A)

Correct Answer: (C)
Electromagnetic torque relation.

Q4. Induction synchronous speed is

(A) sf
(B) P Phi ZN/(60A)
(C) V-I_{aRa}
(D) 120f/P

Correct Answer: (D)
Rotating-field speed.

Q5. Rotor frequency is

(A) sf
(B) P Phi ZN/(60A)
(C) V-I_{aRa}
(D) Phi I_a

Correct Answer: (A)
Slip-frequency relation.

Q6. Select the correct result: DC generator emf is

(A) V-I_{aRa}
(B) P Phi ZN/(60A)
(C) Phi I_a
(D) 120f/P

Correct Answer: (B)
Standard equation.

Q7. Select the correct result: DC motor back emf is

(A) Phi I_a
(B) 120f/P
(C) V-I_{aRa}
(D) sf

Correct Answer: (C)
Motor voltage balance.

Q8. Select the correct result: DC torque is proportional to

(A) 120f/P
(B) sf
(C) P Phi ZN/(60A)
(D) Phi I_a

Correct Answer: (D)
Electromagnetic torque relation.

Q9. Select the correct result: Induction synchronous speed is

(A) 120f/P
(B) sf
(C) P Phi ZN/(60A)
(D) V-I_{aRa}

Correct Answer: (A)
Rotating-field speed.

Q10. Select the correct result: Rotor frequency is

(A) P Phi ZN/(60A)
(B) sf
(C) V-I_{aRa}
(D) Phi I_a

Correct Answer: (B)
Slip-frequency relation.

Q11. Under the standard assumptions, DC generator emf is

(A) $V-I_{aRa}$
(B) Phi I_a
(C) P Phi ZN/(60A)
(D) 120f/P

Correct Answer: (C)
Standard equation.

Q12. Under the standard assumptions, DC motor back emf is

(A) Phi I_a
(B) 120f/P
(C) sf
(D) $V-I_{aRa}$

Correct Answer: (D)
Motor voltage balance.

Q13. Under the standard assumptions, DC torque is proportional to

(A) Phi I_a
(B) 120f/P
(C) sf
(D) P Phi ZN/(60A)

Correct Answer: (A)
Electromagnetic torque relation.

Q14. Under the standard assumptions, Induction synchronous speed is

(A) sf
(B) 120f/P
(C) P Phi ZN/(60A)
(D) $V-I_{aRa}$

Correct Answer: (B)
Rotating-field speed.

Q15. Under the standard assumptions, Rotor frequency is

(A) P Phi ZN/(60A)
(B) $V-I_{aRa}$
(C) sf
(D) Phi I_a

Correct Answer: (C)
Slip-frequency relation.

Q16. Which exam-ready statement completes: DC generator emf is

(A) $V-I_{aRa}$
(B) Phi I_a
(C) 120f/P
(D) P Phi ZN/(60A)

Correct Answer: (D)
Standard equation.

Q17. Which exam-ready statement completes: DC motor back emf is

(A) $V-I_aR_a$
(B) Phi I_a
(C) 120f/P
(D) sf

Correct Answer: (A)
Motor voltage balance.

Q18. Which exam-ready statement completes: DC torque is proportional to

(A) 120f/P
(B) Phi I_a
(C) sf
(D) P Phi ZN/(60A)

Correct Answer: (B)
Electromagnetic torque relation.

Q19. Which exam-ready statement completes: Induction synchronous speed is

(A) sf
(B) P Phi ZN/(60A)
(C) 120f/P
(D) $V-I_aR_a$

Correct Answer: (C)
Rotating-field speed.

Q20. Which exam-ready statement completes: Rotor frequency is

(A) P Phi ZN/(60A)
(B) $V-I_aR_a$
(C) Phi I_a
(D) sf

Correct Answer: (D)
Slip-frequency relation.

Quick Revision: Re-read the formula box, cover the answers, and explain each exam point aloud. A formula is ready for the exam only when its symbols, SI units, assumptions and sign convention are clear.

CHAPTER 5 — ELECTRICAL MEASURING INSTRUMENTS AND RANGE EXTENSION

1. Introduction

Measurement converts electrical quantities into readable indications. Instrument choice requires understanding accuracy, sensitivity, torque production, loading, AC/DC capability and safe range extension.

2. Complete Theory

Measurement fundamentals and torques

Accuracy is closeness to true value; precision is closeness among repeated values. Deflecting torque moves the pointer, controlling torque provides a unique steady position, and damping torque suppresses oscillation without changing final reading.

Errors may be systematic, random or gross.

Hinglish Explanation
Pointer ko move karne ke liye deflecting torque, final position decide karne ke liye controlling, aur jaldi settle karne ke liye damping chahiye.

PMMC, shunts and multipliers

PMMC force on a current-carrying coil in a radial permanent field gives T_d=NBAI. Spring control T_c=k θ makes θ proportional to I, so scale is uniform.

On AC, torque reverses each half-cycle and average is nearly zero; rectification is needed. A low shunt extends current range and a high series multiplier extends voltage range.

Hinglish Explanation
Ammeter ka resistance low aur circuit mein series. Voltmeter ka resistance high aur parallel.

Galvanometer ko galat connect karna instrument damage kar sakta hai.

Moving-iron and dynamometer instruments

Moving-iron torque is proportional to I squared times dL/dtheta, so it works on AC and DC but has nonlinear scale. Dynamometer wattmeter uses current coil in series and pressure coil across load; average torque is proportional to VI cos phi.

Connection and pressure-coil power cause errors.

Hinglish Explanation
MI current direction reverse ho tab bhi I squared positive, so AC/DC dono. Wattmeter mein current coil series aur pressure coil parallel - swap nahi karna.

Energy meter, multimeter and instrument transformers

Induction watt-hour meter torque drives an aluminium disc and a permanent magnet brakes it; revolutions integrate energy. Creeping is slow no-load rotation and is prevented by holes/slots and adjustment.

Digital multimeters offer high input impedance and digital conversion. CTs and PTs safely scale high current/voltage; CT secondary must never be open-circuited while energized.

Hinglish Explanation
Energy meter power nahi, time-integrated energy measure karta hai. CT secondary open karna dangerous high voltage create kar sakta hai; shorting practice follow karo.

4. Engineering Formula Section

Formula Sheet

1. PMMC T_d=NBAI
2. θ=NBAI/k
3. ammeter shunt $R_{sh}=I_{gRg}/(I-I_g)$
4. voltmeter multiplier $R_s=V/I_g-R_g$
5. percentage error=absolute error/true value x100
6. MI torque $T_d=(1/2)I^2$ dL/dtheta
7. wattmeter average torque proportional to VI cos phi
8. energy=power x time

5. Formula Derivations and Solved Examples

For a galvanometer with I_g,R_g converted to ammeter range I, equal voltage across movement and shunt gives $I_{gRg}=(I-I_g)R_{sh}$, hence $R_{sh}=I_{gRg}/(I-I_g)$. For voltmeter range V, total resistance is V/I_g, so series multiplier $R_s=V/I_g-R_g$.

6. Practical Applications

- Electrical testing, billing, control panels, maintenance, protection and commissioning.

7. Short Tricks

- Ammeter low R, series.
- Voltmeter high R, parallel.
- PMMC DC; MI AC/DC.
- Watt-hour meter measures energy.

8. Concept Diagram

```
PMMC RANGE EXTENSION
Ammeter: galvanometer || low R_sh
Voltmeter: galvanometer -- high R_s
Wattmeter: current coil series, pressure coil parallel
```

9. Comparison Table

Instrument	Supply	Scale
PMMC	DC directly	uniform
Moving iron	AC and DC	nonuniform
Dynamometer wattmeter	AC/DC power	power scale
Digital multimeter	AC/DC with internal conversion	digital display

10. Common Mistakes

• Connecting ammeter in parallel.

• Connecting voltmeter in series.

• Opening energized CT secondary.

• Confusing precision with accuracy.

11. Important DSSSB Exam Points

• Shunt/multiplier formulas, torque and connection rules are frequent.

12. Chapter Revision Sheet

Identify measured quantity and safe connection first. Then select operating principle, range extension and error limits.

13. Practice Questions with Solutions

Attempt each question first. The explanation discusses only the correct answer.

Q1. PMMC scale is

(A) uniform
(B) low resistance in parallel
(C) high resistance in series
(D) AC and DC

Correct Answer: (A)
Torque is proportional to current.

Q2. Ammeter shunt is

(A) high resistance in series
(B) low resistance in parallel
(C) AC and DC
(D) must not be open-circuited

Correct Answer: (B)
It bypasses excess current.

Q3. Voltmeter multiplier is

(A) AC and DC
(B) must not be open-circuited
(C) high resistance in series
(D) uniform

Correct Answer: (C)
It limits current.

Q4. Moving iron works on

(A) must not be open-circuited
(B) uniform
(C) low resistance in parallel
(D) AC and DC

Correct Answer: (D)
Torque depends on I squared.

Q5. CT secondary while energized

(A) must not be open-circuited
(B) uniform
(C) low resistance in parallel
(D) high resistance in series

Correct Answer: (A)
Dangerous voltage can result.

Q6. Select the correct result: PMMC scale is

(A) low resistance in parallel
(B) uniform
(C) high resistance in series
(D) AC and DC

Correct Answer: (B)
Torque is proportional to current.

Q7. Select the correct result: Ammeter shunt is

(A) high resistance in series
(B) AC and DC
(C) low resistance in parallel
(D) must not be open-circuited

Correct Answer: (C)
It bypasses excess current.

Q8. Select the correct result: Voltmeter multiplier is

(A) AC and DC
(B) must not be open-circuited
(C) uniform
(D) high resistance in series

Correct Answer: (D)
It limits current.

Q9. Select the correct result: Moving iron works on

(A) AC and DC
(B) must not be open-circuited
(C) uniform
(D) low resistance in parallel

Correct Answer: (A)
Torque depends on I squared.

Q10. Select the correct result: CT secondary while energized

(A) uniform
(B) must not be open-circuited
(C) low resistance in parallel
(D) high resistance in series

Correct Answer: (B)
Dangerous voltage can result.

Q11. Under the standard assumptions, PMMC scale is

(A) low resistance in parallel
(B) high resistance in series
(C) uniform
(D) AC and DC

Correct Answer: (C)
Torque is proportional to current.

Q12. Under the standard assumptions, Ammeter shunt is

(A) high resistance in series
(B) AC and DC
(C) must not be open-circuited
(D) low resistance in parallel

Correct Answer: (D)
It bypasses excess current.

Q13. Under the standard assumptions, Voltmeter multiplier is

(A) high resistance in series
(B) AC and DC
(C) must not be open-circuited
(D) uniform

Correct Answer: (A)
It limits current.

Q14. Under the standard assumptions, Moving iron works on

(A) must not be open-circuited
(B) AC and DC
(C) uniform
(D) low resistance in parallel

Correct Answer: (B)
Torque depends on I squared.

Q15. Under the standard assumptions, CT secondary while energized

(A) uniform
(B) low resistance in parallel
(C) must not be open-circuited
(D) high resistance in series

Correct Answer: (C)
Dangerous voltage can result.

Q16. Which exam-ready statement completes: PMMC scale is

(A) low resistance in parallel
(B) high resistance in series
(C) AC and DC
(D) uniform

Correct Answer: (D)
Torque is proportional to current.

Q17. Which exam-ready statement completes: Ammeter shunt is

(A) low resistance in parallel
(B) high resistance in series
(C) AC and DC
(D) must not be open-circuited

Correct Answer: (A)
It bypasses excess current.

Q18. Which exam-ready statement completes: Voltmeter multiplier is

(A) AC and DC
(B) high resistance in series
(C) must not be open-circuited
(D) uniform

Correct Answer: (B)
It limits current.

Q19. Which exam-ready statement completes: Moving iron works on

(A) must not be open-circuited
(B) uniform
(C) AC and DC
(D) low resistance in parallel

Correct Answer: (C)
Torque depends on I squared.

Q20. Which exam-ready statement completes: CT secondary while energized

(A) uniform
(B) low resistance in parallel
(C) high resistance in series
(D) must not be open-circuited

Correct Answer: (D)
Dangerous voltage can result.

Quick Revision: Re-read the formula box, cover the answers, and explain each exam point aloud. A formula is ready for the exam only when its symbols, SI units, assumptions and sign convention are clear.