Best Basic Electrical Engineering Formulas Important for all JE and Assistant AE(Interview).

A. ELECTRIC CHARGE, CURRENT & VOLTAGE

1 Electric Charge

$$Q = It$$

Charge is the quantity of electricity flowing in a circuit.
It depends on current magnitude and time of flow.

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2 Electric Current

$$I = \frac{Q}{t}$$

Current is the rate of flow of electric charge.
Its unit is Ampere.

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3 Voltage

$$V = \frac{W}{Q}$$

Voltage is work done per unit charge.
It causes current to flow in a circuit.

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4 Ohm's Law

$$V = IR$$

Voltage across a conductor is proportional to current.
Valid only at constant temperature.

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5 Resistance of Conductor

$$R = \rho\frac{L}{A}$$

Resistance increases with length and resistivity.
It decreases with increase in cross-sectional area.

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6 Conductance

$$G = \frac{1}{R}$$

Conductance represents ease of current flow.
Its unit is Siemens (S).

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7 Current Density

$$J = \frac{I}{A}$$

It is current per unit cross-sectional area.
Used in heating and material studies.

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8 Resistivity

$$\rho = R\frac{A}{L}$$

It is a material property independent of size.
Lower resistivity means better conductor.

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9 Electric Field Intensity

$$E = \frac{V}{d}$$

Electric field is voltage gradient.
It represents force per unit charge.

🔟 Potential Gradient

$$PG = \frac{dV}{dx}$$

Rate of change of voltage with distance.
High PG can cause insulation failure.

B. POWER & ENERGY (DC)

11 Electrical Power

$$P = VI$$

Power is rate of energy conversion.
Unit is Watt.

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12 Power in Resistive Circuit

$$P = I^2R$$

Used when current is known.
Represents copper loss also.

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13 Power using Voltage

$$P = \frac{V^2}{R}$$

Used when voltage is known.
Valid only for resistive circuits.

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14 Electrical Energy

$$E = Pt$$

Energy consumed over time.
Unit is Joule or kWh.

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15 Commercial Energy Unit

$$1\ Unit = 1\ kWh$$

Used by electricity boards for billing.
1 kWh = 3.6×10^6 J.

16 Efficiency

$$\eta = \frac{P_{out}}{P_{in}} \times 100$$

Shows performance of electrical devices.
Higher efficiency means lower losses.

17 Power Loss

$$P_{loss} = I^2R$$

Occurs due to resistance of conductors.
Also called copper loss.

18 Load Factor

$$LF = \frac{Average\ Load}{Maximum\ Load}$$

Indicates utilization of electrical system.
Higher LF is desirable.

19 Demand Factor

$$DF = \frac{Max\ Demand}{Connected\ Load}$$

Always less than 1.
Used in power system planning.

20 Diversity Factor

$$DF = \frac{\sum Individual\ Max\ Demand}{System\ Max\ Demand}$$

Always greater than 1.
Improves system economy.

C. DC NETWORKS

21 Series Resistance

$$R_T = R_1 + R_2$$

Same current flows through all resistors.
Voltage divides.

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22 Parallel Resistance

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$$

Same voltage across all branches.
Current divides.

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23 Voltage Divider Rule

$$V_1 = V\frac{R_1}{R_T}$$

Used in series circuits.
Provides required fraction of voltage.

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24 Current Divider Rule

$$I_1 = I\frac{R_2}{R_1+R_2}$$

Used in parallel circuits.
Current inversely proportional to resistance.

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25 Kirchhoff’s Current Law

$$\sum I = 0$$

Total incoming current equals outgoing.
Based on charge conservation.

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26 Kirchhoff's Voltage Law

$$\sum V = 0$$

Algebraic sum of voltages in a loop is zero.
Based on energy conservation.

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27 Maximum Power Transfer

$$R_L = R_{source}$$

Load receives maximum power when matched.
Important in communication systems.

D. AC FUNDAMENTALS

28 RMS Voltage

$$V_{rms} = \frac{V_m}{\sqrt{2}}$$

Effective value of AC voltage.
Produces same heating as DC.

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29 RMS Current

$$I_{rms} = \frac{I_m}{\sqrt{2}}$$

Used in all AC power calculations.
Standard measuring value.

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30 Average Value (Half Cycle)

$$I_{avg} = \frac{2I_m}{\pi}$$

Applicable only for sinusoidal wave.
Used in rectifier analysis.

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31 Form Factor

$$FF = \frac{V_{rms}}{V_{avg}}$$

Indicates waveform shape.
For sine wave = 1.11.

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32 Peak Factor

$$PF = \frac{V_m}{V_{rms}}$$

Shows maximum stress on insulation.
For sine wave = 1.414.

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33 Frequency

$$f = \frac{1}{T}$$

Number of cycles per second.
Unit is Hertz.

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34 Angular Frequency

$$\omega = 2\pi f$$

Used in AC circuit equations.
Unit rad/s.

🔹 E. REACTANCE & IMPEDANCE

35 Inductive Reactance

$$X_L = 2\pi f L$$

Opposition offered by inductor to AC.
Increases with frequency.

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36 Capacitive Reactance

$$X_C = \frac{1}{2\pi f C}$$

Opposition offered by capacitor to AC.
Decreases with frequency.

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37 Impedance

$$Z = \sqrt{R^2 + X^2}$$

Total opposition to AC current.
Measured in ohms.

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38 Phase Angle

$$tan\phi = \frac{X}{R}$$

Indicates phase difference between V and I.
Important for power factor.

- **F. AC POWER**

39 Active Power

$$P = VIcos\phi$$

Useful power doing actual work.
Measured in Watts.

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40 Reactive Power

$$Q = VIsin\phi$$

Power oscillating between source and load.
Measured in VAR.

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41 Apparent Power

$$S = VI$$

Vector sum of real and reactive power.
Measured in VA.

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42 Power Factor

$$\cos\phi = \frac{P}{S}$$

Indicates quality of power usage.
High PF reduces losses.

G. MAGNETISM

43 Magnetic Flux

$$\Phi = BA$$

Total magnetic lines passing through area.
Unit Weber.

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44 Flux Density

$$B = \frac{\Phi}{A}$$

Flux per unit area.
Unit Tesla.

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45 Magnetomotive Force

$$MMF = NI$$

Drives magnetic flux in a magnetic circuit.
Unit Ampere-turn.

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46 Magnetic Field Strength

$$H = \frac{NI}{l}$$

Magnetizing force per unit length.
Unit A/m.

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47 Permeability

$$\mu = \frac{B}{H}$$

Ability of material to carry flux.
Higher μ means better magnetic material.

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48 Reluctance

$$R = \frac{l}{\mu A}$$

Opposition to magnetic flux.
Analogous to resistance.

H. ELECTROMAGNETIC INDUCTION

49 Faraday's Law

$$E = -N\frac{d\Phi}{dt}$$

EMF induced due to changing flux.
Negative sign indicates Lenz's law.

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50 Induced EMF in Conductor

$$E = Blv$$

Used in generators.
Depends on speed and flux density.

I. ENERGY STORAGE

51 Energy in Inductor

$$W = \frac{1}{2}LI^2$$

Stored in magnetic field.
Released when current decreases.

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52 Energy in Capacitor

$$W = \frac{1}{2}CV^2$$

Stored in electric field.
Used in power factor correction.

J. THREE-PHASE SYSTEM

53 3-Phase Power

$$P = \sqrt{3}V_L I_L cos\phi$$

Valid for balanced system.
Most common exam formula.

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54 Star Connection Voltage

$$V_L = \sqrt{3}V_P$$

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55 Star Connection Current

$$I_L = I_P$$

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56 Delta Connection Voltage

$$V_L = V_P$$

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57 Delta Connection Current

$$I_L = \sqrt{3}I_P$$

K. HEATING & TEMPERATURE

58 Joule's Law of Heating

$$H = I^2Rt$$

Heat produced depends on square of current.
Used in heaters and fuses.

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59 Resistance at Temperature t

$$R_t = R_0(1 + \alpha t)$$

Resistance increases with temperature.
Valid for metals.

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60 Fuse Rating

$$I_{fuse} = 1.25 I_{load}$$

Fuse must carry load safely.
Melts during overload.

L. DC MACHINES (BASIC)

61 EMF of DC Generator

$$E = \frac{P\Phi ZN}{60A}$$

Generated EMF depends on flux, speed, and conductors.
Used for both generator and motor basics.

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62 Back EMF of DC Motor

$$E_b = V - I_a R_a$$

Back EMF opposes supply voltage.
Controls motor current and speed.

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63 Torque of DC Motor

$$T \propto \Phi I_a$$

Torque is proportional to flux and armature current.
Explains starting torque behavior.

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64 Speed of DC Motor

$$N \propto \frac{E_b}{\Phi}$$

Speed inversely proportional to flux.
Basis of speed control.

- **M. TRANSFORMER (BASIC)**

65 EMF Equation of Transformer

$$E = 4.44 f N \Phi_m$$

Induced EMF depends on frequency and flux.
Valid for sinusoidal flux.

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66 Transformation Ratio

$$k = \frac{V_2}{V_1} = \frac{N_2}{N_1}$$

Defines step-up or step-down transformer.
Core principle of operation.

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67 Current Ratio

$$\frac{I_1}{I_2} = \frac{N_2}{N_1}$$

Current inversely proportional to turns.
Ensures power balance.

68 Copper Loss

$$P_{cu} = I^2 R$$

Loss due to winding resistance.
Varies with load.

69 Core Loss

$$P_{core} = P_h + P_e$$

Includes hysteresis and eddy current losses.
Independent of load.

70 Transformer Efficiency

$$\eta = \frac{Output}{Output + Losses}$$

Maximum when copper loss equals iron loss.
Important interview concept.

N. INDUCTION MOTOR (BASIC)

71 Synchronous Speed

$$N_s = \frac{120f}{P}$$

Speed of rotating magnetic field.
Depends on frequency and poles.

72 Slip

$$s = \frac{N_s - N}{N_s}$$

Indicates difference between rotor and field speed.
Zero at synchronous speed.

73 Rotor Speed

$$N = N_s(1 - s)$$

Actual running speed of motor.
Always less than synchronous speed.

74 Rotor Frequency

$$f_r = sf$$

Rotor current frequency depends on slip.
Maximum at starting.

75 Rotor Copper Loss

$$P_{rcu} = sP_{ag}$$

Slip portion of air-gap power.
Converted into heat.

76 Mechanical Power

$$P_m = (1 - s)P_{ag}$$

Useful power developed by rotor.
Converted to shaft output.

O. SYNCHRONOUS MACHINE (BASIC)

77 EMF Equation

$$E = 4.44k_w f\Phi T$$

Generated EMF per phase.
Depends on winding factor.

78 Power Developed

$$P = \frac{EV}{X_s} sin\delta$$

Power depends on load angle.
Used in stability analysis.

P. MEASURING INSTRUMENTS

79 Deflecting Torque

$$T_d \propto I$$

Torque causes pointer movement.
Applicable to PMMC instruments.

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80 Controlling Torque

$$T_c \propto \theta$$

Opposes deflecting torque.
Provides steady reading.

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81 Damping Torque

$$T_{damp} \propto \frac{d\theta}{dt}$$

Prevents oscillations.
Ensures quick settling.

Q. CAPACITORS

82 Capacitance

$$C = \frac{Q}{V}$$

Ability to store charge.
Unit Farad.

83 Parallel Plate Capacitor

$$C = \varepsilon \frac{A}{d}$$

Capacitance increases with area.
Decreases with distance.

84 Capacitors in Series

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2}$$

Same charge flows.
Voltage divides.

85 Capacitors in Parallel

$$C_T = C_1 + C_2$$

Same voltage across each.
Total capacitance increases.

- **R. INDUCTORS**

86 Inductance

$$L = \frac{N\Phi}{I}$$

Ability to oppose change in current.
Stores magnetic energy.

87 Induced Voltage

$$v = L\frac{di}{dt}$$

Opposes change in current.
Basis of inductive behavior.

S. RECTIFIERS (BASIC)

88 Rectifier Efficiency

$$\eta = \frac{P_{dc}}{P_{ac}}$$

Measures AC to DC conversion quality.
Higher in full-wave rectifier.

89 Ripple Factor

$$r = \frac{AC\ component}{DC\ component}$$

Indicates smoothness of DC output.
Lower ripple is better.

90 Peak Inverse Voltage (Half Wave)

$$PIV = V_m$$

Maximum reverse voltage across diode.
Important for diode selection.

T. TRANSMISSION & DISTRIBUTION

91 Line Loss

$$P_{loss} = I^2 R$$

Major loss in transmission lines.
Reduced by high voltage.

92 Transmission Efficiency

$$\eta = \frac{P_R}{P_S}$$

Ratio of receiving to sending power.
Higher is desirable.

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93 Voltage Regulation

$$VR = \frac{V_{NL} - V_{FL}}{V_{FL}}$$

Indicates voltage drop under load.
Lower regulation is better.

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94 Kelvin's Law

$$Annual\ Cost = Minimum$$

Economic conductor sizing principle.
Balances capital and loss cost.

U. EARTHING & SAFETY

95 Earth Resistance

$$R = \frac{\rho}{2\pi L} ln\frac{4L}{d}$$

Depends on soil resistivity.
Lower earth resistance improves safety.

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96 Touch Voltage

$$V_t = I_f R_e$$

Voltage experienced by human body.
Must be within safe limits.

V. ILLUMINATION

97 Luminous Intensity

$$I = \frac{F}{\omega}$$

Flux per unit solid angle.
Unit Candela.

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98 Illumination

$$E = \frac{I}{d^2}$$

Light falling per unit area.
Inverse square law.

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99 Luminous Efficiency

$$\eta = \frac{Lumens}{Watts}$$

Measures lighting efficiency.
Higher value means better lamp.

W. BATTERIES

100 Battery Efficiency

$$\eta = \frac{Ah_{out}}{Ah_{in}}$$

Indicates charge retention.
Important for storage systems.

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101 Internal Resistance

$$r = \frac{E-V}{I}$$

Opposes current inside battery.
Causes voltage drop.

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102 Battery Capacity

$$Capacity = I \times t$$

Measured in ampere-hour (Ah).
Defines backup duration.

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103 State of Charge

$$SOC = \frac{Available\ Charge}{Rated\ Charge}$$

Indicates battery health.
Used in EV and UPS.

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104 Charging Power

$$P = VI$$

Power required to charge battery.
Depends on charging mode.

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105 Discharging Power

$$P = VI$$

Power delivered by battery.
Limited by capacity and C-rate.

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106 C-Rate

$$C = \frac{I}{Capacity}$$

Defines charging/discharging speed.
Used in lithium batteries.

◆ X. PROTECTION (BASIC)

107 Short Circuit Current

$$I_{sc} = \frac{V}{Z}$$

Maximum fault current.
Used for breaker selection.

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108 Breaking Capacity

$$BC = \sqrt{3}VI_{sc}$$

Ability of breaker to interrupt fault.
Measured in MVA.

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109 Relay Operating Time

$$t \propto \frac{1}{I}$$

Inverse time characteristic.
Higher fault → faster trip.

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110 CT Ratio

$$CT = \frac{I_P}{I_S}$$

Steps down current for protection.
Standard secondary is 5A or 1A.

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111 PT Ratio

$$PT = \frac{V_P}{V_S}$$

Steps down voltage for metering.
Standard secondary is 110V.

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112 Burden of Instrument

$$Burden = V_S I_S$$

Load connected to CT/PT.
Must be within limits.

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113 Accuracy Class

$$\% \ Error \leq Class$$

Defines instrument precision.
Lower class → higher accuracy.

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114 Relay Sensitivity

$$Sensitivity = \frac{Min\ Fault}{Pickup}$$

Ability to detect low faults.
Higher sensitivity preferred.

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115 Earth Fault Current

$$I_f = \frac{V}{Z_{loop}}$$

Flows through earth during fault.
Used in grounding design.

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116 Step Voltage

$$V_s = I_f \rho$$

Voltage between two feet.
Safety concern in substations.

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117 Touch Voltage

$$V_t = I_f R$$

Voltage between hand and feet.
Must be below safe limit.

118 Safety Factor

$$SF = \frac{Rated}{Operating}$$

Ensures margin of safety.
Used in equipment design.

119 Insulation Resistance

$$IR = \frac{V}{I}$$

Measured using megger.
Higher value indicates healthy insulation.

120 Dielectric Strength

$$DS = \frac{Breakdown\ Voltage}{Thickness}$$

Ability of insulation to withstand voltage.
Critical for cable and equipment design.