

Formulas

Note: This formula sheet is provided as a resource. The sheet may not include all necessary formulas and may contain formulas not required for this exam. Apprentices must apply the formulas to demonstrate their understanding.

Construction/Industrial Electrician (2025) – Level 1-4 Formula Sheet

Constants

$\sqrt{3}$	1.73
π	3.14

Measurement unit abbreviations

E	voltage
Hp	horsepower
I	current
P	power
PF	power factor
R	resistance
VA	volt-ampere

Formulas

	Description	Full Formula	Abbreviated
1.	Apparent Power (kVA)	kilovolt-amperes = (volts x amperes) divided by 1000	$kVA = (V \times A) / 1000$
2.	Synchronous Speed	Revolutions per minute = $(120 \times \text{frequency}) / \text{number of poles (for motors)}$	$RPM = 120F / P$
3.	Transformer Turns Ratio	Ratio of secondary to primary voltage = secondary turns / primary turns Voltage secondary / voltage primary = number of turns secondary / number of turns primary	$V_S / V_P = N_S / N_P$
4.	Transformer Current Ratio	secondary turns / primary turns = primary current / secondary current	$N_S / N_P = I_P / I_S$

5.	Power from Current and Resistance	Power = current squared x resistance (used in resistive circuits)	$P = I^2 R$
6.	Ohm's Law	Current = voltage (or EMF) divided by resistance	$I = E/R$
7.	Electrical Power	Power = voltage (EMF) x current	$P = E \times I$
8.	Power Factor	Power factor = kilowatts / kilovolt-amperes	$PF = kw / kVA$
9.	Three-Phase Power (True Power)	True Power = line voltage x line current x 1.732	True 3Φ Power = $E_L \times I_L \times PF \times 1.732$
10.	Horsepower to Watts Conversion	Electrical power = horsepower x 746	$P \text{ (Watts)} = hp \times 746$
11.	Transformer Cross Multiplication	Primary voltage x number of secondary turns = secondary voltage x number of primary turns	$E_P \times N_S = E_S \times N_P$
12.	Power Factor (W/VA)	Power factor = watts / volt-amperes	$PF = W/VA$
13.	Line-to-Phase Voltage	Voltage = Line voltage / 1.73	$V = V_L / 1.73$
14.	Apparent Power from True and Inductive Power	Apparent power = square root of true power + (inductive power - capacitive) power ²	$VA = \sqrt{P_2 + (VAR_L - VAR_C)^2}$
15.	Wye Voltage Relationship	Phase voltage = line voltage divided by 1.732	Wye EP = $E_L / 1.732$
16.	Total Inductance (Series Inductors)	Total Inductance (Series) = inductor ₁ + inductor ₂ + inductor ₃	Series Inductors $L_T = L_1 + L_2 + L_3$
17.	Total Inductance (Parallel Inductors)	1 / Total Inductance (Parallel) = 1 / inductor ₁ + 1 / inductor ₂ + 1 / inductor ₃	Parallel Inductors $1 / L_T = 1 / L_1 + 1/L_2 + 1 / L_3$

	Description	Full Formula	Abbreviated
18.	Total Capacitance (Parallel Capacitors)	Total Capacitance (Parallel Capacitors) = capacitor ₁ + capacitor ₂ + capacitor ₃	(Parallel Capacitors) $C_T = C_1 + C_2 + C_3$
19.	Total Capacitance (Series Capacitors)	1 / Total Capacitance (Parallel Capacitors) = 1/capacitor ₁ + 1/capacitor ₂ + 1/capacitor ₃	$1 / C_T = 1 / C_1 + 1 / C_2 + 1 / C_3$
20.	Inductive Reactance	Inductive Reactance = 2pi x frequency x inductance	$X_L = 2\pi fL$
21.	Capacitive Reactance	Capacitive Reactance = 1/2pi x frequency x capacitance	$X_C = 1/2\pi fC$
22.	Sides of a right-angle triangle	Hypotenuse (sq) = Side A (sq) + Side B (sq)	$C^2 = A^2 + B^2$
23.	Impedance in RLC Circuit	total impedance = square root of resistance ² + (inductive reactance – capacitive reactance) ²	$Z = \sqrt{R^2 + (X_L - X_C)^2}$
24.	Fault Current	Fault Current = Secondary current/ Impedance	Fault Current = Secondary current/ Impedance
25.	Power Conversion (Watts to BTU/hr)	1 Watt = 3.41 British Thermal Units / hour	1 W = 3.41 BTU / H
26.	Synchronous Speed	Synchronous Speed Formula = 120 x frequency / number of poles	$N = 120F/P$
27.	Horsepower from Torque and Speed	Power (horsepower) = torque (pound-inches) x speed / 63,025	Power (HP) = Torque (lb.in.) x speed / 63,025
28.	Motor Efficiency	Motor Efficiency % = (Power out / Power in) x 100	Motor Efficiency % = (Power out / Power in) x 100
29.	Temperature Conversion (Celsius to Kelvin)	Kelvin = Celsius + 273.15	$T_K = T_C + 273.15$
30.	Motor Slip Percentage	% Slip = (Stator speed – Rotor speed / Stator speed) x 100	% Slip = (Stator speed – Rotor speed / Stator speed) x 100

	Description	Full Formula	Abbreviated
31.	Voltage Regulation (Transformers or Alternators)	% Voltage regulation (Transformers or Alternators) = $\frac{[\text{Voltage}_{\text{no-load}} - \text{Voltage}_{\text{full-load}}]}{\text{Voltage}_{\text{full-load}}} \times 100$	% Voltage regulation (Transformers or Alternators) = $\frac{[\text{Voltage}_{\text{no-load}} - \text{Voltage}_{\text{full-load}}]}{\text{Voltage}_{\text{full-load}}} \times 100$
32.	Three-Phase Current Calculation	3Φ Amps = volt-amperes / (Volts x 1.732)	3Φ Amps = VA / (Volts x 1.732)
33.	Motor Torque Calculation	Motor Torque (Newton-meters) = (Watts x 9.549) / Speed	Motor Torque (N.m) = (W x 9.549) / Speed
34.	Torque Conversion (Foot-Pounds to Newton-Meters)	1 foot.pound = 1.356 Newton-meters	1 ft.lb. = 1.356 N.m
35.	Torque Calculation (in ft.lb)	Torque (foot.pounds.) = (horsepower x 5252) / Speed	Torque (ft.lb.) = (HP x 5252) / Speed
36.	Three-Phase Apparent Power	Three-phase Apparent Power (volt-amperes) = line-to-line voltage x line current x 1.732	3Φ Apparent Power (VA) = $E_L \times I_L \times 1.732$
37.	Temperature Conversion (Celsius to Fahrenheit)	Fahrenheit = Celsius x 9/5 + 32	$T_F = T_C \times 9/5 + 32$
38.	Volume Conversion (Gallons to Cubic Inches)	1 imperial gallon = 277.419 cubic inches	1 gallon = 277.419 in. ³
39.	R Factor Conversion	R Factor = Thermal resistance x 5.68	R Factor = RSI x 5.68
40.	Resistance Calculation	Resistance = conductivity of the material x length of the material / Cross-sectional area	$R = \frac{KL}{CMA}$
41.	Total Resistance (Series)	Total Resistance = resistance ₁ + resistance ₂ + resistance ₃ (series)	$R_T = R_1 + R_2 + R_3$ (series)
42.	Effective (RMS) Value Calculation	Effective Value = Peak Value x 0.707	Effective Value = Peak Value x 0.707
43.	Angle Theta Calculator	Angle theta = inverse cosine of the power factor	Angle Theta = $1 / \cos \text{PF}$
44.	Total Current in a Parallel AC Circuit	Total Current = square root of resistive current	$I_T = \sqrt{I_R^2 + (I_{XL} - I_{XC})^2}$ (parallel)

	Description	Full Formula	Abbreviated
		$\text{sq} + (\text{Inductive current} - \text{capacitive current})^2$	
45.	Time Constant in an RC Circuit	Time Constant = Resistance x Capacitance	$\text{Tau (T)} = RC$
46.	Time Constant in an RL Circuit	Time Constant = Inductance / Resistance	$\text{Tau (T)} = L / R$
47.	Time Constant (Tau) Percentage	$\text{Tau (T)} = 63.2\%$	$\text{Tau (T)} = 63.2\%$
48.	Average Output Voltage of a Half-Wave Rectifier	Single phase half – wave rectifier: maximum value x 0.318	1 – Φ half – wave rectifier: maximum value x 0.318
49.	Average Output Voltage of a Full-Wave Rectifier	Single phase full – wave rectifier: maximum value x 0.637	1 – full – wave rectifier: maximum value x 0.637
50.	Average Output Voltage of a Three-Phase Half-Wave Rectifier	Three phase half – wave rectifier: maximum value x 0.827	3 – half – wave rectifier: maximum value x 0.827
51.	Average Output Voltage of a Three-Phase Full-Wave Rectifier	Three phase – full – wave rectifier: maximum value x 0.955	3 – full – wave rectifier: maximum value x 0.955
52.	Magnification Factor (Rm)	Magnification Factor (Rm) = Constant x Voltage + 1	$R_m = kV + 1$
53.	Horsepower Calculation from Torque and RPM	Horsepower Calculation from Torque and RPM = $\frac{(2\pi) \times \text{torque} \times \text{revolutions per minute}}{33\,000}$	$hp = \frac{(2\pi) \times \text{torque} \times \text{rpm}}{33\,000}$
54.	Instantaneous Voltage in an AC Circuit	Instantaneous voltage = Maximum (peak) voltage x Sin x angle (in degrees or radians)	$E_{\text{INST}} = E_{\text{MAX}} \times \sin \angle \theta$

	Description	Full Formula	Abbreviated
			<i>P</i> = power <i>V</i> = voltage <i>I</i> = current <i>R</i> = resistance
55.	Ohm's Law	Voltage = Current x Resistance	$E = I \times R$
56.	Total Resistance (Parallel)	Total resistance in a parallel circuit = 1 divided by the sum of (1 divided by R1 + 1 divided by R2 + 1 divided by R3)	$R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$
57.	Reciprocal Resistance Formula	Reciprocal Resistance Formula equals 1 divided by R ₁ , R ₂ , and R ₃ in parallel	$1/R_T = 1/R_1 + 1/R_2 + 1/R_3$
58.	Current from Power & Resistance	Current equals the square root of power divided by resistance	$I = \sqrt{P/R}$
59	Voltage Drop	Voltage Drop = Resistivity constant x current x length of the circuit / Circular Mil Area	$E_D = KIL / CMA^*$
60	Reactive Power and Current	Effective Capacitive Voltage = Reactive power (in volt-amp reactive, VARs) for the capacitive component / Capacitive current (amps)	$EC = VAR_{Sc}/I_c$