Resistor Color Code Guide

Band Positions and Roles

Position	Color Code Role	Description	Formula Contribution
Band 1	1st Significant Digit (D_1)	Represents the first digit of the resistance value	$D_1 \times 10$
Band 2	2nd Significant Digit (D_2)	Represents the second digit of the resistance value	$D_2 \times 1$
Band 3	Multiplier (M)	The power of ten by which the two digits (D_1, D_2) are multiplied. It determines the magnitude (in ohms)	× 10^M
Band 4	Tolerance (T)	Indicates the percentage deviation (accuracy) of the actual resistance from the marked value	± T%

Color Code Reference Table

Color	Digit (Bands 1 & 2)	Multiplier (Band 3)	Tolerance (Band 4)
Black	0	$\times 10^0$ (× 1)	—
Brown	1	$\times 10^1$ (× 10)	± 1%
Red	2	$\times 10^2$ (× 100)	± 2%
Orange	3	$\times 10^3$ (× 1k)	—
Yellow	4	$\times 10^4$ (× 10k)	—
Green	5	$\times 10^5$ (× 100k)	± 0.5%
Blue	6	$\times 10^6$ (× 1M)	± 0.25%
Violet	7	$\times 10^7$ (× 10M)	± 0.1%
Grey	8	$\times 10^8$ (× 100M)	± 0.05%
White	9	$\times 10^9$ (× 1G)	—
Gold	—	$\times 10^{-1}$ (× 0.1)	± 5%
Silver	—	$\times 10^{-2}$ (× 0.01)	± 10%

Calculation Formula

The total resistance **R** (in Ω) is calculated as:

$$R = (D_1D_2) \times 10^M \pm T%$$

Where:

- D_1 = First digit (Band 1)
- D_2 = Second digit (Band 2)
- M = Multiplier exponent (Band 3)
- T = Tolerance percentage (Band 4)

Example

For a resistor with bands: **Red, Violet, Orange, Gold**

- Band 1 (Red) = 2
- Band 2 (Violet) = 7
- Band 3 (Orange) = × 10^3
- Band 4 (Gold) = ± 5%

Calculation: R = (27) × 10^3 = **27,000 Ω = 27 kΩ ± 5%**

⚛️ Fundamental Physical Constants

Constant	Symbol	Value (SI Units)
Boltzmann constant	k	$1.3807 × 10^{-23} JK^{-1}$
Gas constant	R	$8.314 J mol^{-1} K^{-1}$
Elementary charge	e	$1.602 × 10^{-19} C$
Gravitational constant	G	$6.674 × 10^{-11} N·m^2·kg^{-2}$
Speed of light	c	$2.998 × 10^8 m·s^{-1}$
Avogadro's number	N_a	$6.022 × 10^{23} mol^{-1}$
Planck constant	h	$6.626 × 10^{-34} J·s$
Speed of light	c	$2.998 × 10^8 m·s^{-1}$
Electron mass	m_1	9.109
Permittivity of free space	ε_0	$8.854 × 10^{-12} C^2·N^{-1}·m^{-2}$
Permeability of free space	μ_0	$4\pi × 10^{-7} T·m·A^{-1}$

🧪 Element Properties (Appendix D & Tables 23-1, 23-2)

| Element | Z | Atomic Mass (g/mol) | Density (g·cm⁻³)| | Melting (°C) | Boiling (°C) | Specific Heat (J/g·°C) | |---|---|---|---|---|---|---| | Hydrogen | 1 | 1.008 | 0.0000837 | −259.3 | −252.9 | 14.3 | | Helium | 2 | 4.0026 | 0.000166 | −272.2 | −268.9 | 5.19 | | Carbon | 6 | 12.011 | 2.25 | 3550 | — | 0.709 | | Nitrogen | 7 | 14.007 | 0.001165 | −210.0 | −195.8 | 1.04 | | Oxygen | 8 | 15.999 | 0.001331 | −218.8 | −183.0 | 0.918 | | Neon | 10 | 20.180 | 0.000839 | −248.6 | −246.0 | 1.03 | | Copper | 29 | 63.55 | 8.96 | 1084.6 | 2562 | 0.385 | | Silver | 47 | 107.87 | 10.49 | 961.8 | 2162 | 0.235 | | Gold | 79 | 196.97 | 19.32 | 1064.2 | 2856 | 0.129 |

📐 Commonly Used Physics Formulas

Electricity & Circuits

Formula	Description	Expression
Ohm's Law	Relationship between voltage, current, and resistance	$V = I · R$
Power	Electrical power dissipation	$P = I · V = I² · R = \frac{V²}{R}$
Parallel Resistors	Equivalent resistance in parallel	$\frac{1}{R_{eq}} = \frac{1}{R₁} + \frac{1}{R₂} + … $
Coulomb's Law	Force between two charges	$F = k · \frac{q₁q₂}{r²}$
Electric Field	Field created by a charge	$E = \frac{F}{q} = k · \frac{q}{r²}$
Capacitor Discharge	Voltage decay over time	V(t) = $V₀e^{-t⁄Rc}$

Thermodynamics

Formula	Description	Expression
Work	Thermodynamic work	W = PΔV
First Law	Energy conservation	ΔU = Q − W
Ideal Gas Law	Equation of state	PV = nRT
Entropy (Isothermal)	Entropy change at constant temperature	ΔS = nR ln($V₂/V₁$)
Entropy (Isobaric)	Entropy change at constant pressure	ΔS = nC_p ln($T₂/T₁$)
Carnot Efficiency	Maximum theoretical efficiency	η = 1 − Tc/T_h

Kinetic Theory & Statistical Mechanics

Formula	Description	Expression
Kinetic Energy per Molecule	Average translational KE	(3/2)kT
RMS Speed	Root-mean-square molecular speed	v_{rms} = √(3kT/m)

Electromagnetism

Formula	Description	Expression
Faraday's Law	Induced EMF from changing magnetic flux	$E = -d\Phi_B/dt$, where $\Phi_B = BA \cos \theta$