

Prefixes

a=10⁻¹⁸, f=10⁻¹⁵, p=10⁻¹², n=10⁻⁹, μ = 10⁻⁶, m=10⁻³, c=10⁻², k=10³, M=10⁶, G=10⁹, T=10¹², P=10¹⁵

Physical Constants

$$k = 1/4\pi\epsilon_0 = 8.988 \text{ GN}\cdot\text{m}^2/\text{C}^2 \text{ (Coulomb's Law)}$$

$$\epsilon_0 = 1/4\pi k = 8.854 \text{ pF/m (permittivity of space)}$$

$$e = 1.602 \times 10^{-19} \text{ C (proton charge)}$$

$$m_e = 9.11 \times 10^{-31} \text{ kg (electron mass)}$$

$$m_p = 1.67 \times 10^{-27} \text{ kg (proton mass)}$$

Units

$$N_A = 6.02 \times 10^{23} / \text{mole (Avogadro's \#)}$$

$$1 \text{ u} = 1 \text{ g}/N_A = 1.6605 \times 10^{-27} \text{ kg (mass unit)}$$

$$1.0 \text{ eV} = 1.602 \times 10^{-19} \text{ J (electron-volt)}$$

$$1 \text{ V} = 1 \text{ J/C} = 1 \text{ volt} = 1 \text{ joule/coulomb}$$

$$1 \text{ F} = 1 \text{ C/V} = 1 \text{ farad} = 1 \text{ C}^2/\text{J}$$

$$1 \text{ A} = 1 \text{ C/s} = 1 \text{ ampere} = 1 \text{ coulomb/second}$$

$$1 \Omega = 1 \text{ V/A} = 1 \text{ ohm} = 1 \text{ J}\cdot\text{s}/\text{C}^2$$

Vectors

Written \vec{V} or \mathbf{V} , described by magnitude= V , direction= θ or by components (V_x, V_y).

$$V_x = V \cos \theta, \quad V_y = V \sin \theta,$$

$$V = \sqrt{V_x^2 + V_y^2}, \quad \tan \theta = \frac{V_y}{V_x}. \quad \theta \text{ is the angle from } \vec{V} \text{ to } +x\text{-axis.}$$

Addition: $\mathbf{A} + \mathbf{B}$, head to tail. Subtraction: $\mathbf{A} - \mathbf{B}$ is $\mathbf{A} + (-\mathbf{B})$, $-\mathbf{B}$ is \mathbf{B} reversed.

Trig summary

$$\sin \theta = \frac{(\text{opp})}{(\text{hyp})}, \quad \cos \theta = \frac{(\text{adj})}{(\text{hyp})}, \quad \tan \theta = \frac{(\text{opp})}{(\text{adj})}, \quad (\text{opp})^2 + (\text{adj})^2 = (\text{hyp})^2.$$

$$\sin \theta = \sin(180^\circ - \theta), \quad \cos \theta = \cos(-\theta), \quad \tan \theta = \tan(180^\circ + \theta), \quad \sin^2 \theta + \cos^2 \theta = 1.$$

OpenStax Chapter 18 Equations

Charges:

$$Q = \pm Ne, \quad \Delta Q_1 + \Delta Q_2 = 0, \quad e = 1.602 \times 10^{-19} \text{ C.}$$

Electric Force:

$$F = k \frac{Q_1 Q_2}{r^2}, \quad k = 8.988 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2, \quad F = \frac{Q_1 Q_2}{4\pi\epsilon_0 r^2}, \quad \epsilon_0 = \frac{1}{4\pi k} = 8.854 \text{ pF/m.}$$

$$\vec{F} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3 + \dots \quad \text{superposition of many forces.}$$

$$F_x = F_{1x} + F_{2x} + F_{3x} + \dots \quad \text{superposition of } x\text{-components of many forces.}$$

$$F_y = F_{1y} + F_{2y} + F_{3y} + \dots \quad \text{superposition of } y\text{-components of many forces.}$$

Electric Field:

$$\vec{E} = \frac{\vec{F}}{q}, \quad q = \text{test charge.} \quad \text{Or: } \vec{F} = q\vec{E}.$$

$$|\vec{E}| = E = k \frac{Q}{r^2} = \frac{Q}{4\pi\epsilon_0 r^2}, \text{ due to point charge. Negative } Q \text{ makes inward } \vec{E}, \text{ positive } Q \text{ makes outward } \vec{E}.$$

$$\vec{E} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 + \dots \quad \text{superposition of many electric fields.}$$

$$E_x = E_{1x} + E_{2x} + E_{3x} + \dots \quad \text{superposition of } x\text{-components of many electric fields.}$$

$$E_y = E_{1y} + E_{2y} + E_{3y} + \dots \quad \text{superposition of } y\text{-components of many electric fields.}$$

$$E = k \frac{Q}{r^2} = \text{electric field around a point charge or } \textit{outside} \text{ a spherical charge distribution.}$$

OpenStax Chapter 19 Equations

Potential Energy and Work:

$W_{ba} = F_E d \cos \theta =$ work done by electric force F_E on test charge, in displacement d from a to b .

$W_{ba} = -q\Delta V = -q(V_b - V_a) =$ work done by electric force on a test charge, moved from a to b .

$\Delta PE = q\Delta V = q(V_b - V_a) =$ change in electric potential energy of the system. Also: $\Delta PE = -W_{ba}$.

$\Delta KE + \Delta PE = 0$, or, $\Delta KE = -\Delta PE = -q\Delta V$, principle of conservation of mechanical energy.

$\Delta KE + \Delta PE = W_{nc}$, change in mechanical energy when nonconservative forces are present.

Potential:

$\Delta V = \frac{\Delta PE}{q} =$ definition of change in electric potential.

$\Delta V = Ed =$ potential change in a uniform electric field.

$V = k\frac{Q}{r} =$ potential produced by a point charge or *outside* a spherical charge distribution.

$PE = qV =$ potential energy for a test charge at a point in a field.

$PE = k\frac{Q_1 Q_2}{r_{12}} =$ potential energy of a pair of charges.

Capacitance:

$Q = CV$, $C = \kappa\epsilon_0\frac{A}{d}$, $E = V/d$, capacitor equations.

$U = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C} =$ stored energy.

$E = \frac{Q/A}{\epsilon_0} =$ electric field strength very near a charged conductor.

OpenStax Chapter 20 Equations

Electric current:

$I = \frac{\Delta Q}{\Delta t}$, or $\Delta Q = I\Delta t$, definition of current.

$V = IR$, or $I = V/R$, Ohm's law.

$R = \rho\frac{L}{A} =$ calculation of resistance.

$\rho_T = \rho_0[1 + \alpha(T - T_0)] =$ temperature-dependent resistivity.

Electric power:

$P = IV$, $P = I^2R$, $P = V^2/R$, $P =$ instantaneous energy/time.

Alternating current:

$V = V_0 \sin(2\pi ft) =$ time-dependent AC voltage. $I = I_0 \sin(2\pi ft) =$ time-dependent AC current.

$V_{\text{rms}} = \sqrt{V^2} = V_0/\sqrt{2} =$ root-mean-square voltage. $I_{\text{rms}} = \sqrt{I^2} = I_0/\sqrt{2} =$ root-mean-square current.

AC power in resistors:

$\bar{P} = \frac{1}{2}I_0^2R = \frac{1}{2}V_0^2/R = \frac{1}{2}I_0V_0 =$ average power. $\bar{P} = I_{\text{rms}}^2R = V_{\text{rms}}^2/R = I_{\text{rms}}V_{\text{rms}} =$ average power.