**Possibly useful relations:**

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|---|---|---|
| $T(K) = T(^\circ C) + 273.15$ | $T(^\circ F) = \frac{9}{5}T(^\circ C) + 32^\circ$ | $\Delta L = \alpha L_0 \Delta T$ |
| $\Delta V = \beta V_0 \Delta T$ | $PV = nRT$ | $PV = NkT$ |
| $\overline{\mathrm{K}} = \frac{1}{2}m\overline{v^2} = \frac{3}{2}kT$ | monoatomic: $E_{\mathrm{int}} = \frac{3}{2}nRT$ | $v_{\mathrm{rms}} = \sqrt{\frac{3kT}{m}}$ |
| $f(v) = 4\pi N(\frac{m}{2\pi kT})^{\frac{3}{2}}v^2 e^{-}(\frac{1}{2}mv^2/kT)$ | | $\Delta N = f(v)dv$ |
| $Q = mc\Delta T$ | $Q = \int_{T_1}^{T_2} mc\, dT$ | $Q = mL_V$ |
| $Q = mL_f$ | $Q = \Delta E_{\mathrm{int}} + W$ | $\mathrm{dW} = \mathrm{PdV}$ |
| adiabatic: $PV^\gamma = \mathrm{const.}$ | $\gamma = C_P/C_V$ | $\epsilon = \frac{\lvert W\rvert}{\lvert Q_H\rvert} = 1 - \frac{\lvert Q_L\rvert}{\lvert Q_H\rvert}$ |
| $\epsilon_{\mathrm{Carnot}} = 1 - \frac{T_L}{T_H}$ | $CP_{\mathrm{ref}} = \frac{Q_L}{W}$ | $CP_{\mathrm{hp}} = \frac{Q_H}{W}$ |
| $CP_{\mathrm{ref}}^{\mathrm{Carnot}} = T_L/(T_H - T_L)$ | $CP_{\mathrm{hp}}^{\mathrm{Carnot}} = 1/(1 - T_L/T_H)$ | $dS = \frac{dQ}{T}$ |
| $\Delta S = \int(\frac{dQ}{T})_{\mathrm{reversible}}$ | $\Delta S_{\mathrm{closed}} \geq 0$ | $S = k\ln W$ |
| $F = k\frac{Q_1 Q_2}{r^2}$ | $\vec{F}_1 = \vec{F}_{12} + \vec{F}_{13} + ...$ | $\vec{E} = \frac{\vec{F}}{q}$ |
| $E = k\frac{Q}{r^2}$ | $E = 2k\lambda/r$ | $E = 2\pi k\sigma$ |
| $E = \sigma/\epsilon_0$ | $\vec{p} = Q\vec{l}$ | $\vec{\tau} = \vec{p} \times \vec{E}$ |
| $U = -\vec{p}\cdot\vec{E}$ | $\int \vec{E}\cdot d\vec{A} = Q_{\mathrm{encl}}/\epsilon_0$ | $\phi_E = \int \vec{E}\cdot d\vec{A}$ |
| $V = U/q$ | $V_B - V_A = -\int \vec{E}\cdot d\vec{l}$ | $V = \frac{kQ}{r}$ |
| $V = \Sigma_i V_i$ | $E = -\frac{dV}{dl}$ | $Q = CV$ |
| $C = K\epsilon_0\frac{A}{d}$ | $U = \frac{QV}{2} = \frac{CV^2}{2} = \frac{Q^2}{2C}$ | $C = KC_0$ |
| $\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + ....$ | $C_p = C_1 + C_2 + ...$ | $u = \frac{1}{2}\epsilon_0 E^2$ |
| $I = \frac{dQ}{dt}$ | $V = IR$ | $R = \rho\frac{L}{A}$ |
| $\rho = \rho_0(1 + \alpha\Delta T)$ | $\sigma = 1/\rho$ | $P = IV$ |
| $P = \frac{V^2}{R} = I^2 R$ | $P_{\mathrm{ave}} = \frac{1}{2}I_0 V_0 = I_{\mathrm{rms}}V_{\mathrm{rms}}$ | $I = neAv_d$ |
| $V = V_0\sin(2\pi ft)$ | $I = I_0\sin(2\pi ft)$ | $I_{\mathrm{rms}} = \frac{I_0}{\sqrt{2}}$ ; $V_{\mathrm{rms}} = \frac{V_0}{\sqrt{2}}$ |
| $R_s = R_1 + R_2 + R_3...$ | $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + ....$ | $V = \mathcal{E} - Ir$ |
| $\tau = RC$ | $V_C = \mathcal{E}(1 - e^{-t/\tau})$ | $Q = Q_0 e^{-t/\tau}$ |
| $\vec{F} = q\vec{v}\times\vec{B}$ | $r = \frac{mv}{qB}$ | $\vec{F} = I\vec{l}\times\vec{B}$ |
| $\mu = NIA$ | $\tau = \vec{\mu}\times\vec{B}$ | $U = -\vec{\mu}\cdot\vec{B}$ |
| $B = \frac{\mu_0 I}{2\pi R}$ (straight wire) | $B = \frac{\mu_0 I}{2R}$ (center of loop) | $B = \mu_0 nI$ (inside solenoid) |
| $\frac{F}{l} = \frac{\mu_0 I_1 I_2}{2\pi d}$ | $\mathcal{E}_H = Bv_d l$ | $\int \vec{B}\cdot d\vec{l} = \mu_0 I_{\mathrm{encl}}$ |

**(over)**

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|---|---|---|
| $\Phi_B = \int \vec{B} \cdot d\vec{A}$ | $\mathcal{E} = -N\frac{\Delta\Phi_B}{\Delta t} = \int \vec{E} \cdot d\vec{l}$ | $\mathcal{E} = NBA\omega \sin(\omega t)$ |
| $\frac{V_s}{V_p} = \frac{N_s}{N_p} = \frac{I_p}{I_s}$ | $\mathcal{E} = Blv$ | $d\vec{B} = \frac{\mu_0 I}{4\pi}\frac{d\vec{l}\times\hat{r}}{r^2}$ |
| $\mathcal{E}_1 = -M\frac{dI_2}{dt}$ | $\mathcal{E}_1 = -L\frac{dI}{dt}$ | $L_{\mathrm{solenoid}} = \frac{\mu_0 N^2 A}{l}$ |
| $U = \frac{1}{2}LI^2$ | | $u = \frac{B^2}{2\mu_0}$ |
| $I = \frac{V_0}{R}(1 - e^{-t/\tau})$ | $I = \frac{V_0}{R}(e^{-t/\tau})$ | $\tau = L/R$ |
| $V_0 = I_0 Z$ | $X_L = \omega L$ | $X_C = 1/\omega C$ |
| $Z = \sqrt{R^2 + (X_C - X_L)^2}$ | $\cos\phi = R/Z$ | $P_{\mathrm{ave}} = I_{\mathrm{rms}} V_{\mathrm{rms}} \cos\phi$ |
| $\omega_0 = 1/\sqrt{LC}$ | | |

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|---|---|---|
| $k = 1.38 \times 10^{-23}$ J/K | $N_A = 6.022 \times 10^{23}$ | $R = 8.315$ J/mol $\cdot$ K |
| $R = kN_A = 0.0821 \frac{\mathrm{atm \cdot L}}{\mathrm{mol \cdot K}}$ | one atmosphere = 760 mm Hg = $10^5$ Pa | |
| 1 cal = 4.186 J | 1 eV = $1.60 \times 10^{-19}$ J | $q_e = -1.60 \times 10^{-19}$ C |
| $k = 9.00 \times 10^9$ Nm$^2$/C$^2$ | $\epsilon_0 = 8.85 \times 10^{-12} \frac{\mathrm{C^2}}{\mathrm{Nm^2}}$ | $\mu_0 = 4\pi \times 10^{-7} \frac{\mathrm{T \cdot m}}{\mathrm{A}}$ |
| $c = 3.00 \times 10^8$ m/s | | |
| $\cos\theta$ = adj./hyp. | $\sin\theta$ = opp./hyp. | $\tan\theta = \sin\theta / \cos\theta$ |
| | $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ | |