# PHYS 1111 Formulas

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| | Angular | Linear |
|---|---|---|
| Acceleration | $\alpha = \dfrac{\Delta\omega}{\Delta t}$ | $a = \dfrac{\Delta v}{\Delta t}$ |
| Moment of inertia | $I = \Sigma m_i r_i^2$ | $m = \Sigma m_i$ |
| Kinetic energy | $K_r = \dfrac{1}{2} I\omega^2$ | $K_t = \dfrac{1}{2} m v^2$ |
| Torque/Force | $\tau = I\alpha$ | $F = ma$ |
| Work | $W = \tau\Delta\theta$ | $W = Fs$ |
| Power | $P = \tau\omega$ | $P = Fv$ |
| Momentum | $L = I\omega$ | $p = mv$ |
| Equilibrium | $\Sigma\tau = 0$ | $\Sigma F = 0$ |
| Precession of gyroscope | $\Omega = \dfrac{\Delta\phi}{\Delta t} = \dfrac{\lvert\tau_w\rvert}{\lvert L\rvert} = \dfrac{wr}{I\omega}$ | |
| Young's modulus | $Y = \dfrac{F_\perp / A}{\Delta l / l_0}$ | |
| Bulk modulus | $B = \dfrac{\Delta p}{\Delta V / V_0}$ | |
| Shear modulus | $S = \dfrac{F_{//}/A}{x/h} = \dfrac{F_{//}/A}{\phi}$ | |
| Simple harmonic motion | $T = 2\pi\sqrt{\dfrac{m}{k}}$ | |
| Simple pendulum | $T = 2\pi\sqrt{\dfrac{L}{g}}$ | |
| Speed of transverse wave | $v = \sqrt{\dfrac{F_T}{\mu}}, \quad \mu = \dfrac{M}{L}$ | |
| Open pipe | $\lambda_n = \dfrac{2L}{n}, \quad f_1 = \dfrac{v}{2L}, \quad f_n = n\dfrac{v}{2L} = nf_1 \quad (n = 1,2,3,\ldots)$ | |
| Stopped pipe | $\lambda_n = \dfrac{4L}{n}, \quad f_1 = \dfrac{v}{4L}, \quad f_n = n\dfrac{v}{4L} = nf_1 \quad (n = 1,3,5,\ldots)$ | |
| Power | $P \propto A^2 f^2$ | |
| Sound Intensity | $I = \dfrac{P}{4\pi r^2}$ | |
| Intensity level | $\beta = 10\log\dfrac{I}{I_0}, \quad I_0 = 10^{-12}\mathrm{W/m^2}$ | |
| Beat frequency | $f_{\text{beat}} = f_1 - f_2$ | |
| Doppler effect | $f_L = \dfrac{v + v_L}{v + v_S} f_S$ | |
| Specific heat capacity | $Q = cm\Delta T$ | |
| Phase change | $Q = mL_{f/v}$ | |
| Thermal expansion | $\Delta L = \alpha L_0 \Delta T, \quad \Delta V = \beta V_0 \Delta T, \quad \beta = 3\alpha$ | |
| Heat current | $H = \dfrac{\Delta Q}{\Delta t} = kA\dfrac{T_H - T_C}{L}$ | |

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|---|---|
| Stefan-Boltzmann law | $H = Ae\sigma T^4$ $\quad$ $H_{\text{net}} = Ae\sigma(T^4 - T_s^4)$ |
| Boyle's law | $p \propto 1/V$ |
| Guy-Lussac's law | $p \propto T$ |
| Charles's law | $V \propto T$ |
| Ideal-gas equation | $pV = nRT$ |
| Total translational KE | $U \overset{\text{ideal}}{=} K_{\text{tt}} = \begin{cases} \frac{3}{2}nRT & \text{monatomic} \\ \frac{5}{2}nRT & \text{diatomic} \end{cases}$ |
| Average translational KE | $K_{\text{avt}} = \begin{cases} \frac{3}{2}kT & \text{monatomic} \\ \frac{5}{2}kT & \text{diatomic} \end{cases}$ |
| Root-mean-square speed | $v_{\text{rms}} = \sqrt{\dfrac{3RT}{M}} = \sqrt{\dfrac{3kT}{m}}$ |
| Molar heat capacity | $Q = Cn\Delta T$ $\quad$ $C = Mc$ $\quad$ $C_p = C_V + R$ |
| For monatomic gas | $C_V = \dfrac{3}{2}R$ |
| For diatomic gas | $C_V = \dfrac{5}{2}R$ |
| First law of thermodynamics | $Q = \Delta U + W$ |
| Isothermal (constant $T$) process | $W = p_1V_1 \ln\left(\dfrac{V_2}{V_1}\right)$ $\quad$ $\Delta U = 0,\ Q = W$ |
| Isochoric (constant $V$) process | $W = 0$ $\quad$ $\Delta U = Q$ |
| Isobaric (constant $p$) process | $W = p(V_2 - V_1)$ $\quad$ $\Delta U, Q, W \neq 0$ |
| Adiabatic ($Q = 0$) process | $W = -\Delta U = \dfrac{1}{1-\gamma}(p_1V_1 - p_2V_2)$ |
| | $p_1V_1^\gamma = p_2V_2^\gamma,\quad T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}\quad (\gamma = \dfrac{C_p}{C_V})$ |
| Heat engine | $\lvert Q_H\rvert = \lvert Q_c\rvert + \lvert W\rvert$ $\quad$ $Q_H > 0,\ Q_C < 0,\ W > 0$ |
| Thermal efficiency | $e = \dfrac{W}{Q_H}$ |
| Efficiency of Otto cycle | $e = 1 - \left(\dfrac{V_1}{V_2}\right)^{\gamma-1}$ |
| Refrigerator | $\lvert Q_c\rvert + \lvert W\rvert = \lvert Q_H\rvert$ $\quad$ $Q_H < 0,\ Q_C > 0,\ W < 0$ |
| Performance coefficient | $K = \dfrac{\lvert Q_C\rvert}{W} = \dfrac{\lvert Q_C\rvert}{\lvert Q_H\rvert - \lvert Q_C\rvert} = \dfrac{H}{P}$ |
| Efficiency of Carnot engine | $e = \dfrac{T_H - T_C}{T_H}$ |
| Efficiency of Carnot refrigerator | $K = \dfrac{T_C}{T_H - T_C}$ |
| Entropy | $\Delta S = S_2 - S_1 = \dfrac{Q}{T}$ |