

# Magic™ Physics Formula Sheet

## Kinematics

$$v = \Delta x / \Delta t$$

$$a = \Delta v / \Delta t$$

$$v_f = at + v_i$$

$$x = \frac{1}{2}at^2 + vt + x_i$$

$$v_f^2 = v_i^2 + 2ax$$

## Force

$$F = ma$$

$$F_{\text{spring}} = -kx$$

$$F_n = F_{\perp \text{surface}}$$

$$F_f = F_n \mu$$

## Energy

$$\Delta U = Q + W$$

$$W = Fd = -P\Delta V$$

$$PE_{\text{grav}} = mgh$$

$$KE_{\text{translational}} = \frac{1}{2}mv^2$$

$$PE_{\text{spring}} = \frac{1}{2}kx^2$$

$$P = w/t = Fd/t = Fv$$

$$\Delta S = Q_r/T \quad \text{eff}_{\text{carnot}} = 1 - T_c/T_h = 1 - Q_{\text{out}}/Q_{\text{in}}$$

isobaric constP      adiabatic  $\Delta U = W$   
 isovolumetric  $\Delta U = Q$       isothermal  $Q = -W$

## Momentum

$$p = mv$$

$$F_{\text{net}} = \Delta p / \Delta t$$

$$I = F\Delta t = \Delta p = m\Delta v \quad \text{impulse}$$

$$v_{1i} - v_{2i} = -(v_{1f} - v_{2f})$$

*approach velocity = -separate velocity;*  
*head-on, elastic only*

$$m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f} \quad I\omega = I\omega$$

*momentum is conserved; all*

$$\frac{1}{2}m_1v_{1i}^2 + \frac{1}{2}m_2v_{2i}^2 = \frac{1}{2}m_1v_{1f}^2 + \frac{1}{2}m_2v_{2f}^2$$

*KE is conserved; elastic only*

## Thermal Expansion

$$\Delta L = \alpha L_0 \Delta T$$

$$\Delta A = \gamma A_0 \Delta T \quad \gamma = 2\alpha$$

$$\Delta V = \beta V_0 \Delta T \quad \beta = 3\alpha$$

## Gases

$$PV = nRT \quad R = 0.0821 \text{ L-atm/mol-K}$$

$$U = \frac{3}{2} nRT \quad R = 8.314 \text{ J/mol-K}$$

## Angular

$$\omega = \Delta \theta / \Delta t$$

$$\alpha = \Delta \omega / \Delta t$$

$$\omega_f = \alpha t + \omega_i$$

$$\theta = \frac{1}{2}\alpha t^2 + \omega t + \theta_i$$

$$\omega_f^2 = \omega_i^2 + 2\alpha\theta$$

$$I = \Sigma mr^2$$

$$\tau = I\alpha$$

$$\tau = rF\sin\theta$$

$\theta$  is between lines of r and F

## Units

$$N = \text{kg}\cdot\text{m}/\text{s}^2$$

$$J = \text{N}\cdot\text{m} \quad 1 \text{ cal} = 4.186 \text{ J}$$

$$W = \text{J}/\text{s}$$

$$Sk = \text{N}\cdot\text{s}$$

$$L = \text{J}\cdot\text{s} = \text{kg}\cdot\text{m}^2/\text{s}$$

$$\tau = \text{N}\cdot\text{m}$$

$$I = \text{kg}\cdot\text{m}^2$$

$$\text{Pa} = \text{N}/\text{m}^2 \quad 1 \text{ atm} = 1.01 \text{E}5 \text{ Pa} = 760 \text{ torr}$$

$$K = C + 273.15 \quad F = 9/5C + 32$$

$$\text{Hz} = 1/\text{s}$$

$$F = C/V$$

$$N/C = V/\text{m}$$

$$V = J/C$$

$$\text{amp} = C/\text{s}$$

$$\text{ohm or } \Omega = V/\text{amp}$$

## Angular

$$v_t = r\omega \quad \text{tangential speed}$$

$$a_t = r\alpha \quad \text{tangential accel}$$

$$a_c = v^2/r = r\omega^2 \quad \text{centripetal accel}$$

$$F_c = \frac{ma_c}{r} = \frac{mv^2}{r} \quad \text{centripetal force}$$

$$a = \sqrt{a_t^2 + a_c^2} \quad \text{total accel}$$

$$v = \sqrt{rg} \quad \text{critical velocity}$$

$$G = 6.67 \text{E}^{-11} \text{ Nm}^2/\text{kg}^2$$

$$\frac{mv^2}{r} = \frac{Gm_1m_2}{r^2} \quad \frac{T_1^2}{r_1^3} = \frac{T_2^2}{r_2^3}$$

$$F_{\text{grav}} = \frac{Gm_1m_2}{r^2} \quad \text{(Kepler's Law)}$$

## Fluid Mechanics

$$\rho = m/V \quad \text{density}$$

$$P = F/A \quad \text{pressure}$$

$$Av = Av \quad \text{const flow speed}$$

$$B = P_2A - P_1A = mg = \rho Vg \quad \text{buoyant F}$$

$$P + \frac{1}{2}\rho v^2 + \rho gy = P + \frac{1}{2}\rho v^2 + \rho gy$$

## Newton's Laws

1<sup>st</sup> – inertia

2<sup>nd</sup> –  $F = ma$

3<sup>rd</sup> – action-reaction

## Oscillators

$$T = 2\pi\sqrt{m/k} \quad \text{period of spring-object}$$

$$T = 2\pi\sqrt{l/g} \quad \text{period of pendulum}$$

$$x = A\cos(2\pi ft) \quad \text{when } t=0 \text{ at peak}$$

$$v = -A\omega\sin(2\pi ft)$$

$$a = -A\omega^2\cos(2\pi ft) \quad \theta = 2\pi ft = \omega t$$

$$\omega = 2\pi f = \sqrt{k/m} \quad \omega = 2\pi f = \sqrt{k/m}$$

$$v = \pm\sqrt{k/m} (A^2 - x^2)$$

## Sound

$$I = P/A$$

$$\text{dB} = 10\log I/I_0 \quad I_0 = 10^{-12} \text{W/m}^2$$

$$I r^2 = I r^2$$

$$v = f\lambda \quad v = \sqrt{F/\mu} \quad v = 331 + 0.6T \text{ (C)}$$

$$f_o = f_s (v+v_o)/(v-v_s)$$

$$\text{open } f_n = nV/(2L) = n_f l \quad n=1,2,3\dots$$

$$\text{closed } f_n = nV/(4L) = n_f l \quad n=1,3,5\dots$$

## Electric

$$F = kQ_1Q_2 / r^2 \quad k = 9 \times 10^9 \text{N}\cdot\text{m}^2/\text{C}^2$$

$$C = 6.25 \times 10^{-18} \text{ elections}$$

$$\text{electron} = 1.6 \times 10^{-19} \text{C}$$

$$E = F/q = kQ/r^2$$

$$V = kq/r = PE/q$$

$$C = Q/V = k\epsilon_0 A/d$$

$$\epsilon_0 = 8.85 \times 10^{-12} \text{ m}^{-3} \text{ kg}^{-1} \text{ s}^4 \text{ A}^2$$

$$1/2 QV = 1/2 CV^2 = Q^2/(2C)$$

$$\text{Parallel } V = V_1 = V_2 = V_3$$

$$C = C_1 + C_2 + C_3$$

$$\text{Series } Q = Q_1 = Q_2 = Q_3$$

$$1/C = 1/C_1 + 1/C_2 + 1/C_3$$

$$I = Q/t \text{ (amp} = \text{C/s)}$$

$$V = IR \text{ (}\Omega = \text{V/amp)}$$

$$R = \rho l/A$$

$$P = IV = I^2R = V^2/R$$

*Any collision:*

$e$  = coefficient of restitution,  $1$ =elastic,

$0$ =completely inelastic

$$v_{1p} = v_{1x}\cos\theta + v_{1y}\sin\theta$$

“velocity parallel to the line of action”

$$v_{1n} = -v_{1x}\sin\theta + v_{1y}\cos\theta$$

“perpendicular,  $n$  stands for normal?”

$$v'_{1p} = v_{1p} \frac{(m_1 - em_2)}{m_1 + m_2} + v_{2p} \frac{(1+e)m_2}{m_1 + m_2}$$

Skip to here if head-on

$$m_1 + m_2 \quad m_1 + m_2$$

$$v'_{1x} = v'_{1p}\cos\theta - v_{1n}\sin\theta$$

$$v'_{1y} = v'_{1p}\sin\theta + v_{1n}\cos\theta$$

swap 1 and 2 for the other object