

PHY 231C FORMULAS

Quadratic Formula

$$ax^2 + bx + c = 0$$

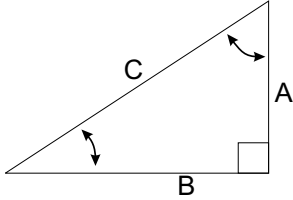
$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Geometry

Circle: circumference= $2\pi R$, area= πR^2

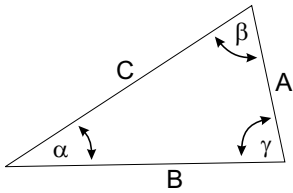
Sphere: area= $4\pi R^2$, volume= $4\pi R^3/3$

Trigonometry



$$\sin \alpha = \frac{A}{C}, \quad \cos \alpha = \frac{B}{C}$$

$$\tan \alpha = \frac{A}{B}$$



$$\frac{\sin \alpha}{A} = \frac{\sin \beta}{B} = \frac{\sin \gamma}{C}$$

$$A^2 + B^2 - 2AB \cos \gamma = C^2$$

Polar Coordinates

$$x = r \cos \theta, \quad y = r \sin \theta$$

$$r = \sqrt{x^2 + y^2}, \quad \tan \theta = y/x$$

SI Units and Constants

quantity	unit	abbreviation
Mass m	kilograms	kg
Distance x	meters	m
Time t	seconds	s
Force F	Newtons	N=kg m/s ²
Energy E	Joules	J=N m
Power P	Watts	W=J/s
Temperature T	°C, °K or °F	$T_{°F} = 32 + (9/5)T_{°C}$
Pressure P	Pascals	Pa=N/m ²

$g = 9.8 \text{ m/s}^2$, $G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$, $0^\circ\text{C} = 273.15^\circ\text{K}$

$R = 8.31 \text{ J}/(\text{mol}^\circ\text{K})$, $N_A = 6.023 \times 10^{23}$

$k_B = R/N_A = 1.38 \times 10^{-23} \text{ J}/^\circ\text{K}$, $1 \text{ cal} = 4.1868 \text{ J}$

$\sigma = 5.67 \times 10^{-8} \text{ W}/(\text{m}^2\text{K}^4)$, $v_{\text{sound}} = 331\sqrt{T/273} \text{ m/s}$.

1-d motion, constant a

$$a = \frac{v_f - v_0}{t}$$

$$v_{\text{av}} = \frac{v_0 + v_f}{2}, \quad (x_f - x_0) = v_{\text{av}} t$$

$$(x_f - x_0) = v_0 t + \frac{1}{2} a t^2 = v_f t - \frac{1}{2} a t^2$$

$$v_f^2 - v_0^2 = 2a(x_f - x_0)$$

Projectile Motion

$$\text{Range} = \frac{v^2}{g} \sin 2\theta, \quad \text{Max. height} = \frac{v_0^2}{2g} \sin^2 \theta$$

Momentum, Force and Impulse

$$p = mv, \quad F = \frac{\Delta p}{\Delta t} = ma, \quad I = F\Delta t = \Delta p$$

Friction: $F_{\text{fric}} = \mu N$

Work, Energy and Power

$$W = \vec{F} \cdot (\vec{r} - \vec{r}_0), \quad KE = \frac{1}{2}mv^2, \quad P = \frac{\Delta E}{\Delta t}$$

Gravity and circular orbits

$$PE = -G\frac{Mm}{r}, \quad \Delta PE = mgh(\text{small } h), \quad F = G\frac{Mm}{r^2} = mg$$

$$a = \frac{v^2}{r}, \quad \frac{GM}{4\pi^2} = \frac{R^3}{T^2}$$

Rotational Motion & Gravity

$$v = \omega r = \frac{2\pi r}{T}, \quad \omega = 2\pi f = \frac{2\pi}{T}, \quad f = 1/T$$

$$\alpha = \frac{\omega_f - \omega_0}{t} = \frac{a}{r}$$

$$L = I\omega = mvr \sin \theta, \quad (\theta = \text{angle between } v \text{ and } r)$$

$$KE = \frac{L^2}{2I} = \frac{1}{2}I\omega^2$$

$$\tau = rF \sin \theta, \quad I\alpha = \tau, \quad I_{\text{point}} = mR^2$$

$$I_{\text{cyl. shell}} = mR^2, \quad I_{\text{sphere}} = \frac{2}{5}mR^2, \quad I_{\text{solid cyl.}} = \frac{1}{2}mR^2.$$

Gases, liquids and solids

$$PV = NRT, \quad \Delta P = \rho gh, \quad \langle \frac{1}{2}mv^2 \rangle = \frac{3}{2}k_B T$$

$$F_{\text{buoyant}} = \rho_{\text{displaced liq.}} V_{\text{displaced liq.}} g$$

Stress = F/A , Strain = $\Delta L/L$, $Y = \text{Stress}/\text{Strain}$

$$\frac{\Delta L}{L} = \frac{F/A}{B} = \frac{-\Delta P}{B}$$

$$P_a + \frac{1}{2}\rho_a v_a^2 + \rho_a g h_a = P_b + \frac{1}{2}\rho_b v_b^2 + \rho_b g h_b$$

$$\Delta L/L = \alpha \Delta T, \quad \Delta V/V = 3\alpha \Delta T$$

$$Q = mC_v \Delta T + mL(\text{if phase trans.}), \quad \Delta Q/\Delta t = \frac{kA(T_b - T_a)}{x_b - x_a}$$

Radiation

$$P = \epsilon \sigma AT^4$$

Thermodynamics

$\Delta U = Q - W$, $W = P\Delta V$, ideal gas: $\Delta U = nC_V \Delta T$

Adiabatic exp: $pV^\gamma = \text{const}$, $TV^{\gamma-1} = \text{const}$

$\gamma = C_p/C_V = 5/3$ for monotonic gas = $7/5$ for diatomic gas

$Q = T\Delta S$, $\Delta S > 0$

Engines: $\epsilon = W/Q_H < (T_H - T_L)/T_H < 1$

Refrigerators and heat pumps: $\epsilon = Q_L/W < T_L/(T_H - T_L)$

Simple Harmonic Motion and Waves

Spring: $F = -kx$, $PE = (1/2)kx^2$, $\omega = \sqrt{k/m}$

$f = \omega/(2\pi)$, $x(t) = A \cos(\omega t - \phi)$, $v = -\omega A \sin(\omega t - \phi)$

Pendulum: $T = 2\pi\sqrt{L/g}$

Waves: $y(x, t) = A \sin[2\pi(ft - x/\lambda + \delta)]$, $v = f\lambda$

$I = \text{const} A^2 f^2$, $I_2/I_1 = R_1^2/R_2^2$

Standing waves: $\lambda_n = 2L/n$

Strings: $v = \sqrt{T/\mu}$, Solid/Liquid: $v = \sqrt{B/\rho}$

Sound: $I = E/(A \cdot \Delta t) = \text{Power}/A$

$I_0 \equiv 10^{-12}$, $\beta = 10 \log_{10}(I/I_0)$, $I = I_0 10^{\beta/10}$

Beat freq. = $|f_1 - f_2|$, Doppler:

$$f_{\text{obs}} = f_{\text{source}}(V_{\text{sound}} \pm v_{\text{obs}})/(V_{\text{sound}} \pm v_{\text{source}})$$

Pipes: same at both ends: $L = \lambda/2, \lambda, 3\lambda/2$

Pipes: open at only one end: $L = \lambda/4, 3\lambda/4, \dots$