PHY 231/231C FORMULAS

Quadratic Formula

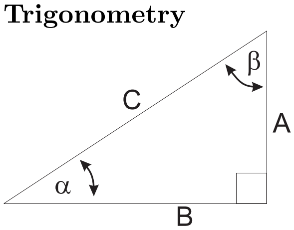
$$ax^2 + bx + c = 0$$

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

Geometry

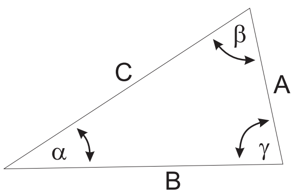
Circle: circumference=$2\pi R$, area=πR^2
Sphere: area=$4\pi R^2$, volume=$4\pi R^3/3$

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	$T_{\circ F} = 32 + (9/5)T_{\circ C}$
Pressure P	Pascals	Pa=N/m^2

$g = 9.81$ m/s^2, G=6.67×10^{-11} Nm^2/kg^2, 0°C=273.15°K
$R = 8.31$ J/(mol°K), $N_A = 6.023 \times 10^{23}$
$k_B = R/N_A = 1.38 \times 10^{-23}$ J/°K, 1 cal=4.1868 J
$\sigma = 5.67 \times 10^{-8}$ W/(m^{2}K^4), $v_{\rm sound} = 331\sqrt{T/273}$ m/s
$c_{\rm ice,H_20,steam}$=$\{0.5, 1.0, 0.48\}$ cal/g°C, $L_{F,V}$=$\{80, 540\}$ cal/g

1-d motion, constant a

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

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

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

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

Momentum, Force and Impulse

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

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

Work, Energy and Power

$$W = Fx\cos\theta, KE = \frac{1}{2}mv^2, \; P = \frac{\Delta E}{\Delta t} = Fv$$

Gravity and circular orbits

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

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

Rotational Motion

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

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

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

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

$$\tau = rF\sin\theta, \; I\alpha = \tau, \; I_{\rm point} = mR^2, \; I_{\rm cyl.shell} = MR^2$$

$$I_{\rm sphere} = \frac{2}{5}MR^2 \; I_{\rm solid\ cyl.} = \frac{1}{2}MR^2, \; I_{\rm sph.\ shell} = \frac{2}{3}MR^2.$$

Gases, liquids and solids

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

$$F_{\rm bouyant} = \rho_{\rm displaced\ liq.}V_{\rm displaced\ liq.}g$$

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

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

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

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

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

$$\text{Poiselle'sLaw} : \Delta V/\Delta t = \pi R^4(P_1 - P_2)/(8\eta L)$$

Radiation

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

Thermodynamics

$\Delta U = Q + W, \quad W = -P\Delta V$, ideal gas: $\Delta U = nC_V\Delta T$
Adiabatic exp: pV^γ =const, $TV^{\gamma-1}$ =const
$\gamma = C_p/C_V$=5/3 for monotonic gas=7/5 for diatomic gas
$Q = T\Delta S$, $\Delta S > 0$
Engines: $\epsilon = W/Q_H < (T_H - T_L)/T_H < 1$, $W = |Q_H| - |Q_L|$
Refrigerators and heat pumps: $\epsilon = Q_L/W < T_L/(T_H - T_L)$

Simple Harmonic Motion and Waves

Spring: $F = -kx$, $PE = (1/2)kx^2$, $\omega = \sqrt{k/m}$
$f = \omega/(2\pi)$, $x(t) = A\cos(\omega t - \phi)$, $v = -\omega A\sin(\omega t - \phi)$
$a = -\omega^2 A\cos(\omega t - \phi)$. 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:
$f_{\rm obs} = f_{\rm source}(V_{\rm sound} \pm v_{\rm obs})/(V_{\rm sound} \pm v_{\rm source})$
Pipes: same at both ends: $L = \lambda/2, \lambda, 3\lambda/2$
Pipes: open at only one end: $L = \lambda/4, 3\lambda/4\cdots$