Quadratic Formula

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

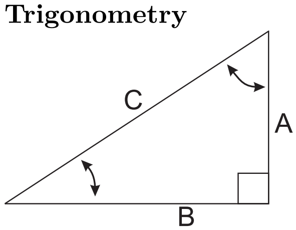
$x = [-b \pm \sqrt{b^2 - 4ac}]/(2a)$

Geometry

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

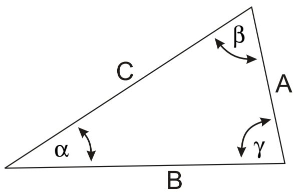
Sphere: area=$4\pi R^2$, volume=$4\pi R^3/3$

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

1 cal=4.1868 J, 1 hp=745.7 W, 1 liter=10^{-3}m^3

$g = 9.81$ m/s^2, G=6.67×10^{-11} Nm^2/kg^2

1 atm=1.013×10^5Pa, 0°C=273.15°K, $N_A = 6.023 \times 10^{23}$

$R = 8.31$ J/(mol°K)=0.0821 L atm/(mol K),

$k_B = R/N_A = 1.38 \times 10^{-23}$ J/K, $\sigma = 5.67 \times 10^{-8}$ W/(m^{2}K^4)

$v_{\rm sound} = 331\sqrt{T/273}$ m/s

H$_2$0: $c_{\rm ice,liq.,steam}$=$\{0.5, 1.0, 0.48\}$ cal/g°C

$L_{F,V}$=$\{79.7, 540\}$ cal/g, $\rho = 1000$ kg/m^3.

1-d motion, constant a

$\Delta x = (1/2)(v_0 + v_f)t$

$v_f = v_0 + at$

$\Delta x = v_0 t + (1/2)at^2$

$\Delta x = v_f t - (1/2)at^2$

$(1/2)v_f^2 - (1/2)v_0^2 = a\Delta x$

Range: $R = (v_0^2/g)\sin 2\theta$

Forces, Work, Energy, Power, Momentum & Impulse

$F = ma$, Gravity: $F = mg, PE = mgh$

Friction: $f = \mu N$, Spring: $F = -kx,\ PE = (1/2)kx^2$

$W = Fx\cos\theta, KE = (1/2)mv^2,\ P = \Delta E/\Delta t = Fv$

$p = mv, I = F\Delta t = \Delta p$

$X_{cm} = (m_1 x_1 + m_2 x_2 + \cdots)/(m_1 + m_2 + \cdots)$

Elastic coll.s: $v_1' - v_2' = -(v_1 - v_2)$

Rotational Motion

$\Delta\theta = (1/2)(\omega_0 + \omega_f)t, \omega_f = \omega_0 + \alpha t$

$\Delta\theta = \omega_0 t + (1/2)\alpha t^2 = \omega_f t - (1/2)\alpha t^2$

$\alpha\Delta\theta = (1/2)\omega_f^2 - (1/2)\omega_0^2$

$\omega = 2\pi/T = 2\pi f, f = 1/T$

Rolling: $a = \alpha r, v = \omega r$

$a_c = v^2/r = \omega v = \omega^2 r$

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

$I_{\rm cyl.shell} = MR^2,\ I_{\rm sphere} = (2/5)MR^2$

$I_{\rm solid\ cyl.} = (1/2)MR^2,\ I_{\rm sph.\ shell} = (2/3)MR^2$

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

$KE = (1/2)I\omega^2 = L^2/(2I), W = \tau\Delta\theta$

Gravity and circular orbits

$PE = -G\frac{Mm}{r},\ \Delta PE = mgh$(small h)

$$F = G\frac{Mm}{r^2}, \quad \frac{GM}{4\pi^2} = \frac{R^3}{T^2}$$

Gases, liquids and solids

$P = F/A,\ PV = nRT,\ \Delta P = \rho gh$

$\langle(1/2)mv^2\rangle = (3/2)k_B T$

ideal monotonic gas: $U = (3/2)nRT = (3/2)PV$

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

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

$\frac{\Delta L}{L} = \frac{F/A}{Y}, \frac{\Delta V}{V} = \frac{-\Delta P}{B}, Y = 3B$

Continuity: $\rho_1 A_1 v_1 = \rho_2 A_2 v_2$

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

Thermal

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

$Q = mC_v\Delta T + mL$(if phase trans.)

Conduction and Radiation

$P = kA(T_b - T_a)/L = A(T_b - T_a)/R, R \equiv L/k$

$P = e\sigma AT^4$

Thermodynamics

$\Delta U = Q + W, \quad W = -P\Delta V,\ Q = T\Delta S,\ \Delta S > 0$

Engines: $W = |Q_H| - |Q_L|$

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

Refrigerators and heat pumps: $W = |Q_H| - |Q_L|$

$\epsilon = Q_L/W < T_L/(T_H - T_L)$

Simple Harmonic Motion and Waves

$f = 1/T,\ \omega = 2\pi f$

$x(t) = A\cos(\omega t - \phi),\ v = -\omega A\sin(\omega t - \phi)$

$a = -\omega^2 A\cos(\omega t - \phi)$

Spring: $\omega = \sqrt{k/m}$

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

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

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

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

Strings: $v = \sqrt{T/\mu}$

Solid/Liquid: $v = \sqrt{B/\rho}$

Sound: $I = {\rm Power}/A = I_0 10^{\beta/10},\ I_0 \equiv 10^{-12}$ W/m^2

Decibels: $\beta = 10\log_{10}(I/I_0)$

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: $L = \lambda/4, 3\lambda/4, 5\lambda/4\cdots$