PHY 231/231C FORMULAS

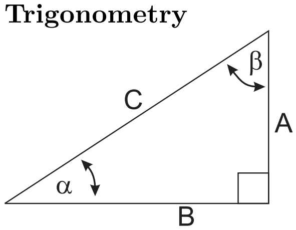
Quadratic Formula

$ax^2 + bx + c = 0$,
$x = [-b \pm \sqrt{b^2 - 4ac}]/(2a)$

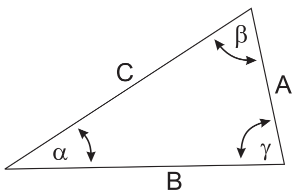
Geometry

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
$g = 9.81$ m/s^2, G=6.67×10^{-11} Nm^2/kg^2
0°C=273.15°K, $N_A = 6.023 \times 10^{23}$
$R = 8.31$ J/(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)
$v_{\text{sound}} = 331\sqrt{T/273}$ m/s
H$_2$0: $c_{\text{ice,liq.,steam}}=\{0.5, 1.0, 0.48\}$ cal/g°C
$L_{F,V}=\{80, 540\}$ cal/g, $\rho = 1.0$ g/cm^3.

1-d motion, constant a

$x = (1/2)(v_0 + v_f)t$
$v_f = v_0 + at$
$x = v_0 t + (1/2)at^2$
$x = v_f t - (1/2)at^2$
$(1/2)v_f^2 - (1/2)v_0^2 = a(x_f - x_0)$

Momentum, Force and Impulse

$p = mv, \ F = ma = \Delta p/\Delta t$
$I = F\Delta t = \Delta p$
Friction: $F_{\text{fric}} = \mu N$
Spring: $F = -kx$

Work, Energy and Power

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

Rotational Motion

$v = \omega r = 2\pi r/T, \quad \omega = \Delta\theta/\Delta t = 2\pi f = 2\pi/T, f = 1/T$
$\alpha = (\omega_f - \omega_0)/t = \frac{a}{r}$
$L = I\omega = mvr\sin\theta$, ($\theta$= angle between v and r)
$KE = (1/2)I\omega^2 = L^2/(2I)$
$\tau = rF\sin\theta, \ I\alpha = \tau, \ I_{\text{point}} = mR^2$
$I_{\text{cyl.shell}} = MR^2, \ I_{\text{sphere}} = (2/5)MR^2$
$I_{\text{solid cyl.}} = (1/2)MR^2, \ I_{\text{sph. shell}} = (2/3)MR^2$
$a = v^2/r = \omega v = \omega^2 r$

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

$P = F/A, \ PV = NRT, \ \Delta P = \rho g h$
$\langle(1/2)mv^2\rangle = (3/2)k_B T$
$F_{\text{bouyant}} = \rho_{\text{displaced liq.}} V_{\text{displaced liq.}} g$
Stress = F/A, Strain = $\Delta L/L$, Y = Stress/Strain
$\frac{\Delta L}{L} = \frac{F/A}{Y}, \frac{\Delta V}{V} = \frac{-\Delta P}{B}, Y = 3B$
Bernoulli: $P_a + \frac{1}{2}\rho_a v_a^2 + \rho_a g h_a = P_b + \frac{1}{2}\rho_b v_b^2 + \rho_b g h_b$

Heat

$\Delta L/L = \alpha\Delta T, \ \Delta V/V = 3\alpha\Delta T$
$Q = mC_v\Delta T + mL$(if phase trans.)

Conduction and Radiation

$P = kA(T_b - T_a)/\Delta x = A(T_b - T_a)/R$,
$R \equiv \Delta X/k$, $P = e\sigma AT^4$

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 (monotonic), =7/5 (diatomic)
$Q = T\Delta S$, $\Delta S > 0$
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: $y(x,t) = A\sin[2\pi(ft - x/\lambda + \delta)]$, $v = f\lambda$
$I = \text{const}A^2 f^2$, $I_2/I_1 = R_1^2/R_2^2$
Standing waves: $\lambda_n = 2L/n$
Strings: $v = \sqrt{T/\mu}$
Solid/Liquid: $v = \sqrt{B/\rho}$
Sound: $I = \text{Power}/A = I_0 10^{\beta/10}$, $I_0 \equiv 10^{-12}$ W/m^2
Decibels: $\beta = 10\log_{10}(I/I_0)$
Beat freq.=$|f_1 - f_2|$
Doppler: $f_{\text{obs}} = f_{\text{source}}(V_{\text{sound}} \pm v_{\text{obs}})/(V_{\text{sound}} \pm v_{\text{source}})$
Pipes: same at both ends: $L = \lambda/2, \lambda, 3\lambda/2$
Pipes: open at only one end: $L = \lambda/4, 3\lambda/4, 5\lambda/4 \cdots$