Equations - Mechanics

Kinematics

Linear		*Rotational*
$s = s_0 + v_0t + \frac{1}{2} at^2$		$\theta = \theta_0 + \omega_0 t + \frac{1}{2} \alpha t^2$
$v_f = v_0 + at$		$\omega_f = \omega_0 + \alpha t$
$v_f^2 = v_0^2 + 2ad$		$\omega_f^2 = \omega_0^2 + 2\alpha\theta$
d (range) = $v_0^2 \sin(2\theta)/g$		$\alpha = \Delta\omega/t$
$h_{max} = \sin^2\theta v_0^2/2g$		
	Tang velocity	$v_t = \omega r$
	Centripetal accel	$a_c = v_t^2/r = \omega^2 r$
	Tang accel	$a_t = \alpha r$

Force/work

$F = ma = Gm_1m_2/r^2$	$\tau = rF\sin\theta \quad = I\alpha$	
$p = vm = Ft$	$L = I\omega = rp$	[only around fixed axis or axis of symmetry]
$J = Ft = \Delta p$	$\Delta L = r\Delta p = \tau t = Fsr$	
$W = Fd = \Delta E$	$= \tau\theta$	
$E = \frac{1}{2}mv^2 = \frac{1}{2}kx^2 = mgh = Fd = \frac{1}{2}p^2/m$	$= \tau\theta, \frac{1}{2}I\omega^2$	
$P = E/t = Fv$	$= \tau\theta t = \tau\omega$	
$F_g = Gm_1m_2/r^2$	$F_{drag} = \frac{1}{2}C\rho Av^2$	
[$v_{f1} = v_{i1}(m_1 - m_2)/(m_1 + m_2)$	$v_{f2} = v_{i1}(2m_1)/(m_1 + m_2)$	*2 obj collision, w obj 2 at rest*]
$v_{term} = \sqrt{(2mg/C\rho A)}$	$T = 2\pi\sqrt{(r/g)}$ (orbital period)	

Moment of inertia of various objects

Object	*Center*		*Edge/End*
Thin Rod	$1/12\ ML^2$		$1/3\ ML^2$
Plane/slab	$1/12\ Ma^2$		$1/3\ Ma^2$
Cylinder/solid	$\frac{1}{2} MR^2$	(hoop)	MR^2
Sphere/solid	$2/5\ MR^2$	(hollow)	$2/3\ MR^2$
General	cMR^2		
Rolling Downhill	$v_{cm} = \sqrt{2gh/(1+c)}$		$a_{cm} = g\sin\theta/(1+c)$

Parallel Axis Theorem $I = I_{cm} + Md^2$

M = Mass R = Radius L = Length a = area d = distance I = moment of inertia cm – center mass

SHM

$f = 1/T = (1/2\pi)\sqrt{k/m}$ $T = 2\pi\sqrt{m/k}$

$\omega = d\phi/dt = 2\pi f = 2\pi/T$ $\phi = \omega t + \phi_0$ $\Delta\phi = \omega t$

$x(t) = A\cos(2\pi t/T) = A\cos(\omega t + \phi_0) = A\cos(2\pi f t)$ $\mu = \frac{T}{v^2}$

$v(t) = dx/dt = -\omega A\sin(\omega t + \phi_0) = -v_{max}\sin(2\pi t/T) = -v_{max}\sin(2\pi f t)$ $v = \sqrt{\frac{T}{\mu}}$

$a(t) = d_2x/dt^2 = -\omega^2 A\cos(\omega t + \phi_0)$ $a_x = -\omega^2 x = -k/m\ x$

$u = Ae^{-V/Vo}$

Legend

s, r, d or h = distance or radius or height	θ, Φ = angle	A = area
v = velocity	ω = angular velocity	f = frequency
a = acceleration	α = angular acceleration	g = acceleration of gravity
a_t = tangential acceleration	a_c = centripetal acceleration	G = gravitational constant
F = force	τ = torque	T = period; tension (N)
Q, q = charge (C)	λ = charge/length	η = charge/area
E = Energy; electric field (J; N/C or V/m)	W = work (J)	Φ = electric flux (Vm or Nm^2/C)
U = potential energy	K = Kinetic Energy (J)	P = power (W; J/s)
J = Joules (Nm or kg m^2/s^2)	u_E = elec energy density (J/m^3)	ρ = charge density; (Q/m^3)
μ = linear density (kg/m); *permeability Const ($4\pi x10^{-7}Tm/A$)*		
ε = permittivity const ($8.85x10^{-12}$ C^2/Nm^2)	K = $1/2\pi\varepsilon_0$ ($8.99x10^9$ Nm^2/C^2)	κ = dielectric constant
C = capacitance (F)/Coulomb (C)	V = voltage or electrical pot. (V)	p = dipole moment (Cm or D)

Identities

$x = \cos\theta$ $y = \sin\theta$ $\theta = \tan^{-1} y/x$

$\tan\theta = \sin\theta / \cos\theta$

$\sin 2\theta = 2\sin\theta \cos\theta$

p=sq

Other

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

Constants

$\varepsilon = 8.55x10^{-12}$ C^2/Nm^2 $K=1/2\pi\varepsilon=8.99x10^9$ Nm^2/C^2

$G=6.67x10^{-11}N$ $(q)e^- = 1.6x10^{-19}C$ $(m)=9.11x10^{-31}kg$ $(m)p^+ = 1.67x10^{-27}$ kg