Planet Holloway Physics

Equations Sheet

Kinematics

$\bar{v} = \frac{\Delta x}{\Delta t}, \quad v = \frac{dx}{dt}$

$\Delta x = v_0 t + \frac{1}{2}at^2, \quad \Delta x = v_f t - \frac{1}{2}at^2$

$a = \frac{\Delta v}{\Delta t}, \quad a = \frac{dv}{dt}$

$v_f^2 = v_0^2 + 2a\Delta x$

$\Delta x = \frac{1}{2}\left(v_0 + v_f\right)t$

Forces

$F = ma, \quad w = mg$, (use a FBD!!)

$F_f = \mu F_N$ (μ_s is a maximum for static friction therefore can be <u>less than</u> calculated, and μ_k is constant)

$F_s = -kx, \; F = \frac{dp}{dt}$

$W = Fd\cos\theta, \quad W = \int Fdx\cos\theta$

$W = \Delta K, \quad W = -\Delta U$

Energy

$K = \frac{1}{2}mv^2, \; K_r = \frac{1}{2}I\omega^2$

$U_g = mgh, \quad U_g = -G\frac{m_1 m_2}{r}, \; U_s = \frac{1}{2}kx^2$

$U_i + K_i + W_{nc} = U_f + K_f$

$W = Fd\cos\theta, \quad W = \int Fdx\cos\theta$

$W = \Delta K, \quad W = -\Delta U$

$P = \frac{W}{t}, \quad P = Fv$

Momentum

$p = mv, \quad p_i = p_f, \quad F = \frac{dp}{dt}$

$J = \Delta mv, \quad J = Ft, \quad J = \int Fdt$

$L = I\omega, \quad L = mvr_\perp, \quad L = mvr\sin\theta$

Gravity/Orbits

$F_g = G\frac{m_1 m_2}{r^2}$, (G=6.67*10^-11)

$v_{esc} = \sqrt{\frac{2GM_e}{R_e}}$

$F_c = \sum F_r, \quad F_c = ma_c, \quad F_c = m\frac{v^2}{r}, \quad F_c = m\omega^2 r$

Rotational Kinematics

$s = r\theta$

$v = r\omega$

$a_t = r\alpha$

$\Delta\theta = \omega_0 t + \frac{1}{2}\alpha t^2$

$\bar{\omega} = \frac{\Delta\theta}{\Delta t}, \quad \omega = \frac{d\theta}{dt}$

$\alpha = \frac{\Delta\omega}{\Delta t}, \quad \alpha = \frac{d\omega}{dt}$

$\Delta\theta = \frac{1}{2}\left(\omega_i + \omega_f\right)t$

Torque/Rotation

$I = \sum mr^2, \quad I = \int r^2 dm, \quad I = \int r^2 \rho dV$

$I = mr^2$, $I = \frac{1}{2}mr^2$, $I = \frac{2}{5}mr^2$, $I = \frac{2}{3}mr^2$,

$I = \frac{1}{12}ml^2$, $I = \frac{1}{3}ml^2$

$I_p = I_{cm} + Md^2$

$x_{cm} = \frac{\sum mr}{\sum m}$

$K_r = \frac{1}{2}I\omega^2$

$\tau = I\alpha$, $\tau = rF\sin\theta$ (RHR for direction)

$L = I\omega$, $L = mvr_{\perp}$, $L = mvr\sin\theta$

$T^2 = k_s a^3$, $k_s = \frac{4\pi^2}{Gm_s}$, (k=1 for AU's & yrs)

Oscillations

$T_p = 2\pi\sqrt{\frac{l}{g}}$

$T_s = 2\pi\sqrt{\frac{m}{k}}$

$T_{cp} = 2\pi\sqrt{\frac{I}{mgd}}$

$\omega = \frac{2\pi}{T}$

$x = A\cos(\omega t + \phi)$

$v = -A\omega\sin(\omega t + \phi)$

$a = -A\omega^2\cos(\omega t + \phi)$, $a = \frac{d^2x}{dt^2}$, $a = -\omega^2 x$

Fluids

$P = \frac{F}{A}$, $P = \frac{dF}{dA}$

$\rho = \frac{m}{V}$

$P = P_0 + \rho g h$

$F_{buoy} = \rho V g$

$A_1 v_1 = A_2 v_2$

$P_1 + \rho g h_1 + \frac{1}{2}\rho {v_1}^2 = P_2 + \rho g h_2 + \frac{1}{2}\rho {v_2}^2$

Thermodynamics

$\Delta L = \alpha L_0 \Delta T$

$\Delta A = \gamma A_0 \Delta T$, $\gamma = 2\alpha$

$\Delta V = \beta V_0 \Delta T$, $\beta = 2\alpha$

$PV = nRT = N k_B T$

R=8.31 J/(mol K)=0.00821 (L atm)/(mol K)

$U = K_{total} = \frac{3}{2} nRT = \frac{3}{2} N k_B T$

$v_{rms} = \sqrt{\frac{3k_B T}{m}} = \sqrt{\frac{3RT}{M}}$, k_B=1.38*10^-23 J/K

$H = \frac{kA\Delta T}{L}$, k=J/(s m ºC)

$Q = mC\Delta T$

$Q = \pm mL$

$W_{sys} = -P\Delta V$, $W_{enviro} = P\Delta V$

$\Delta U = Q + W_{sys}$

$W_{engine} = |Q_h| - |Q_c|$

$e_c = 1 - \frac{T_c}{T_h} = \frac{W_{engine}}{|Q_h|} = \frac{|Q_h| - |Q_c|}{|Q_h|}$

$\Delta S = \frac{Q_R}{T}$

$COP_{engine} = \frac{|Q_h|}{W_{engine}}$, $COP_{pump} = \frac{|Q_c|}{W_{engine}}$

Waves/Sound/Optics

$v = f\lambda$

$v = \sqrt{\frac{F}{\mu}}$, $\mu = \frac{m}{L}$

$v = (331)\sqrt{\frac{T}{273}}$

$f_0 = f_s\left(\frac{v + v_0}{v - v_s}\right)$

$\lambda_0 = \lambda_s - \frac{v_s}{f_s}$

$f_b = |f_2 - f_1|$

$f_n = \frac{n}{2L}\sqrt{\frac{F}{\mu}}$

$f_{nopen} = n\frac{v}{2L}$, $f_{nclosed} = n\frac{v}{4L}$

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

$n \equiv \frac{c}{v}$, $n = \frac{\lambda_0}{\lambda_n}$

$E = hf$, h=6.63*10^-34 J s

$\sin\theta_c = \frac{n_2}{n_1}$

$\frac{1}{s_0} + \frac{1}{s_i} = \frac{1}{f}$

$M = \frac{-s_i}{s_0}$, $h_i = |M| h_0$

$\delta_{bright} = r_2 - r_1 = m\lambda = d\sin\theta_{bright}$

$\delta_{dark} = r_2 - r_1 = \left(m + \frac{1}{2}\right)\lambda = d\sin\theta_{dark}$

$$Y_{bright} = \frac{\lambda L}{d} m,\ Y_{dark} = \frac{\lambda L}{d}(m + \frac{1}{2})$$

$$2nt = (m + \frac{1}{2})\lambda,\ 2nt = m\lambda$$

$$\sin\theta_{bright} = (m + \frac{1}{2})\frac{\lambda}{a},\ \sin\theta_{dark} = m\frac{\lambda}{a}\ F = k\frac{|Qq|}{r^2},$$

Electricity

$$k = \frac{1}{4\pi\varepsilon_0}$$

$$E = k\frac{|Q|}{r^2} = \frac{F}{q}$$

$$\Delta V = \Delta k\frac{q}{r} = \frac{\Delta U}{q} = -Ed$$

$$U_e = -qEd = q\Delta V = k\frac{Qq}{r}$$

$$U_c = \frac{1}{2}C\Delta V^2 = \frac{1}{2}Q\Delta V = \frac{1}{2}\frac{Q^2}{C}$$

$$C = \frac{Q}{\Delta V} = \varepsilon_0\frac{A}{d}$$

$$\frac{1}{C_s} = \sum\frac{1}{C_n}$$

$$C_p = \sum C_n$$

$$R = \rho\frac{l}{A}$$

$$R_s = \sum R_n$$

$$\frac{1}{R_p} = \sum\frac{1}{R_n}$$

$$I = \frac{\Delta Q}{\Delta t}$$

$$\Delta V = IR$$

$$P = I\Delta V = I^2R = \frac{\Delta V^2}{R}$$

Magnetism

$$F = qvB\sin\theta = IlB\sin\theta$$

$$B = \frac{\mu_0}{2\pi}\frac{I}{r},\ k' = \frac{\mu_0}{2\pi} = 2\times10^{-7}$$

$$\phi = BA\cos\theta$$

$$\varepsilon = -\frac{\Delta\phi}{\Delta t} = Blv$$

Atomic/Nuclear

$$v = f\lambda,\ c = v = 3.0\times10^8\ m/s$$

$$E = hf = \frac{hc}{\lambda} = pc$$

$$\lambda = \frac{h}{p}$$

$$K = hf - \phi$$

$$E_{electron} = -2.178\times10^{18}\frac{Z^2}{n^2}\text{ Joules}$$

$$E_{electron} = 6.242\times10^{18}\frac{Z^2}{n^2}\text{ eV}$$

$$E = mc^2$$