PHYS211, Fact Sheet 2

Gravitation

$F_g = G\frac{m_1 m_2}{R^2}$; G = 6.67 x 10^{-11} $m^3/kg \cdot s^2$ (or $N \cdot m^2/kg^2$); g = 9.81 m/s^2

If the planet does not spin, $g = G\frac{M}{R^2}$; $a_h = G\frac{M}{(R+h)^2}$; $U = -G\frac{m_1 m_2}{R}$

M_{earth} = 5.98 x 10^{24} kg, R_{earth} = 6.37 x 10^6 m, M_{sun} = 1.99 x 10^{30} kg, $d_{earth-moon}$ = 3.84 x 10^8 m, $d_{earth-sun}$ = 1.50 x 10^{11} m

$v_{orbit} = \sqrt{\frac{GM}{R}}$, $v_{escape} = \sqrt{\frac{2GM}{R}}$, G - gravitational constant, M - mass of the planet, R - distance from the satellite to the center of the planet. Energy of a satellite: $E = -G\frac{mM}{2R}$, $K = |E|$

Circular and Rotational Motion

$\omega = \frac{\Delta\theta}{\Delta t}$, $\alpha = \frac{\Delta\omega}{\Delta t}$, $a_\tau = \alpha \cdot r$, v = ω R; $\theta = \omega t + \frac{\alpha t^2}{2}$, $\omega = \omega_o + \alpha \cdot t$, $\omega^2 = \omega_o^2 + 2\alpha(\theta - \theta_o)$

θ - angle, ω - angular velocity (angular frequency), α - angular acceleration, r - radius

f = 1/T; ω = 2π/T = 2πf

Centripetal acceleration: $a_c = \frac{v^2}{r} = \omega^2 r$, tangential acceleration $a_\tau = ar$,

centripetal force: $F_c = m\frac{v^2}{r} = m\omega^2 r$

Moment of inertia: $I_z = \Sigma m_i r_i^2$; solid sphere about diameter: $I_z = \frac{2MR^2}{5}$, solid cylinder about axis: $I_z = \frac{MR^2}{2}$, thin rod of length l about a perpendicular line through center: $I_z = \frac{Ml^2}{12}$; parallel axis theorem: $I_z = I_{cm} + Md^2$

Torque: τ = rF sinθ (θ - angle between $\vec{r}$ and $\vec{F}$), $\tau = r_\perp F$; "Newton's 2nd law" for rotation: $\tau_z = \alpha I_z$

Kinetic energy of rotation: $K_{rot} = \frac{I_z \omega^2}{2}$; work: W = τ · θ , power: P = τ · ω

Angular momentum: $\vec{L} = I\vec{\omega}$, L = Iω , L = $r_{arm}P = r_{arm} \cdot mv = m(r_{arm})^2\omega$; τ = ΔL/ Δt; conservation of angular momentum: if $\tau_{ext} = 0$, then L = Iω = const.

Fluid Statics

Density: ρ = m/V, pressure: P = F/A, pressure due to the weight of the fluid: P = ρgh, total pressure h meters below the surface: P = ρgh + P_{atm} . Archimedes's Principle: the buoyant force on an object equals the weight of the fluid displaced: $F_b = m_{fluid}g = \rho_{fluid}V_{displ.}g$. Bernoulli's equation: $P + \frac{\rho v^2}{2} + \rho g y = const$

Temperature, Kinetic Theory, Gas Laws

t°F = (9/5)t°C + 32, t°C = (5/9)(t°F - 32), T = t°C + 273.15; $< K_{molecule} >= \frac{3}{2}kT$

Ideal gas law: PV = NkT, PV = nRT, n = m/M

N- number of molecules, n - number of moles, m - mass, M - mass of 1 mole

k = 1.38x10^{-23} J/K, R = 8.31 J/mol·K, N_A = 6.02x10^{23}/mol, k = R/ N_A

Heat

1 cal = 4.186 J, Q = mcΔT (c - specific heat); Q = $mL_{melting-freezing}$,Q = $mL_{vaporization-condensation}$ (L - latent heat)

First Law of Thermodynamics: Q = ΔU + W_{12}

Oscillations, Waves, Sound

$x = A\sin(\omega t + \delta)$, $\omega = 2\pi f = 2\pi/T$, $f = 1/T$; mass attached to a spring: $T = 2\pi\sqrt{m/k}$, simple pendulum: $T = 2\pi \sqrt{L/g}$

$y = A\sin(\omega t - kx)$, $\lambda = vT = v/f$; intensity: $I = P/A = E/\Delta t \cdot A$ (P - power carried through area A, E - energy)

β (dB) $= 10 \log_{10} (I/I_o)$, $I_o = 10^{-12}$ Wt/m^2

Relativity

$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$\Delta t = \frac{\Delta t_0}{\sqrt{1-\frac{v^2}{c^2}}} = \gamma\, \Delta t_o\,;\ L = L_0\sqrt{1-\frac{v^2}{c^2}} = L_o/\gamma;\ K = \left(\sqrt{P^2c^2 + m^2c^4} - mc^2\right) = (\gamma - 1)\, mc^2;$$

Momentum: $\vec{P} = \frac{m\vec{v}}{\sqrt{1-\frac{v^2}{c^2}}} = \gamma m\vec{v}$; rest energy: $E_o = mc^2$; total energy: $E = \frac{mc^2}{\sqrt{1-\frac{v^2}{c^2}}} = \gamma\, mc^2$;

$E = K + E_o$

---

giga: 10^9, mega: 10^6, kilo: 10^3 (1 kg = 1000 g = 10^3 g, 1 km = 10^3 m), centi: 10^{-2} (1 cm = 10^{-2} m = 1/100 m, 1 m = 100 cm), milli: 10^{-3} (1 mm = 10^{-3} m, 1 m = 1000 mm), micro: 10^{-6}, nano: 10^{-9}

1 in. = 2.54 cm = 0.0254 m, 1 ft = 0.305 m, 1 mi = 1609 m, 1 gal = 3.76 l = $3.76 \cdot 10^{-3}$ m^3, 1 lb = 4.45 N