PHYSICS 101 EQUATION SHEET

Prof. Doney 2/17/11

CONSTANTS/CONVERSIONS

1 mi = 1.609 km = 5280 ft

1 in. = 2.54 cm   1 m = 3.28 ft

1 liter = 1000 mL = 1000 cm^3 = $1x10^{-3}$ m^3

1 kg = 2.2 lb   1 lb force = 4.45 N

1 kcal = 4180 J   1 hp = 746 watt

1 Watt = 1 J/s   1 Pa = 1 N/m^2

1 atm = $1.013x10^5$ N/m^2 = 14.7 psi

g = 9.8 m/s^2 G = $6.67x10^{-11}$ Nm^2/kg^2

GENERAL MOTION

Avg speed = distance / time

Avg velocity = displacement / time

$$\bar{v} = \frac{x_2 - x_1}{t_2 - t_1} = \frac{\Delta x}{\Delta t}$$

$$\bar{a} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{\Delta v}{\Delta t}$$

CONSTANT ACCELERATION (x-dir)

$x = v_{avg}\, t$ $x = x_o + v_o t + ½ at^2$

$v = v_o + at$ $v^2 = v_o^2 + 2a (x – x_o)$

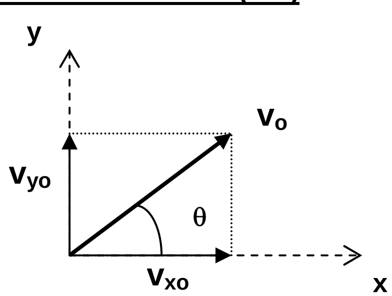
$\bar{v} = ½ (v + v_o)$ *where*: $\Delta x = x – x_o$

CONSTANT ACCELERATION (y-dir)

$y = y_o + v_o t + ½ gt^2$ $v = v_o + gt$

$v^2 = v_o^2 + 2g (y – y_o)$ *where:* $\Delta y = y – y_o$

PROJECTILE MOTION (2-D)



x-direction: $a_x = 0$

$v_{xo} = v_o \cos\theta$

$v_x = v_{xo}$ $x = x_o + v_{xo} t$

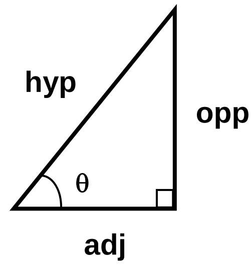
y-direction: $a_y = - g$ *(when choose +y up)*

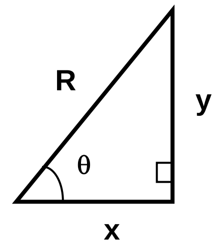
$v_{yo} = v_o \sin\theta$ $v_y = v_{yo} + gt$

$y = y_o + v_{yo}t + ½ gt^2$ $v_y^2 = v_{yo}^2 + 2g (y – y_o)$

VECTORS & RIGHT TRIANGLES

Note: right (90°) angle is required





"SOH CAH TOA"

$$\sin\theta = \frac{opp}{hyp} \qquad \cos\theta = \frac{adj}{hyp}$$

$$\tan\theta = \frac{opp}{adj} = \frac{\sin\theta}{\cos\theta}$$

$$\theta = \tan^{-1}\left(\frac{opp}{adj}\right)$$

$hyp^2 = adj^2 + opp^2$ *or* $x^2 + y^2 = R^2$

$hyp = \sqrt{adj^2 + opp^2}$ *or* $R = \sqrt{x^2 + y^2}$

FRICTION

$F_{FR} = \mu F_N$ μ_s = static, μ_k = kinetic

W = mg

For *NO MOTION*: a = 0, $\Sigma F_x = 0$, $\Sigma F_y = 0$

When *MOTION*: a ≠ 0, because $\Sigma F_x \neq 0$ and/or $\Sigma F_y \neq 0$

Use Newton's 2nd Law: $\Sigma F = m\, a$

CIRCULAR MOTION (constant velocity)

$$a_{radial} = a_{centripetal} = \frac{v^2}{r} \qquad T = \frac{1}{f} \qquad v = \frac{2\pi r}{T}$$

$$\Sigma F = m\, a_c = m\frac{v^2}{r} \qquad F_{grav} = G\frac{m_1 m_2}{r^2}$$

WORK & ENERGY

$W = F_{perp}\, d = F\, d \sin\theta$

P = W / t = Fd / t = F v

$KE = ½ m v^2$ $W_{NET} = \Delta KE = KE_2 – KE_1$

$PE_{grav} = mgh$ $F_{elastic/spring} = k\, x$ $PE_{elastic/spring} = ½ k x^2$

CONSERVATIVE FORCES ONLY:

$E_2 = E_1$ = constant $KE_2 + PE_2 = KE_1 + PE_1$

NON-CONSERVATIVE: $W_{NC} = \Delta KE + \Delta PE$

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MOMENTUM & COLLISIONS

P = m v $\quad \Delta P = F \Delta t$

ELASTIC: $m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$

$\Delta v_i = \Delta v_f$ *or* $v_{2i} - v_{1i} = -(v_{2f} - v_{1f})$

INELASTIC: $m_1v_{1i} + m_2v_{2i} = (m_1 + m_2)\, v_f$

C.O.M. & MOMENT OF INERTIA

$X_{com} = \dfrac{\Sigma m_i x_i}{m_{total}} \qquad Y_{com} = \dfrac{\Sigma m_i y_i}{m_{total}}$

$I_x = \sum m_i y_i^2 \qquad I_y = \sum m_i x_i^2$

CIRCULAR MOTION (constant accel)

360° = 2π = 1 rev. $\quad s = r\,\Delta\theta$

$\omega = \dfrac{\Delta\theta}{\Delta t} \qquad \alpha = \dfrac{\Delta\omega}{\Delta t}$

$v_{tan} = r\,\omega \qquad a_{tan} = r\,\alpha$

$a_{radial} = a_c = \dfrac{v^2}{r} = \dfrac{(r\omega)^2}{r} = r\,\omega^2$

$T = \dfrac{1}{f} \qquad \omega = 2\,\pi\,f$

ROTATIONAL MOTION (constant accel)

α = constant $\qquad \theta = \frac{1}{2}(\omega_o + \omega)\,t$

$\Delta\theta = \omega_o t + \frac{1}{2}\alpha t^2 \qquad \omega = \omega_o + \alpha t$

$\omega^2 = \omega_o^2 + 2\,\alpha\,\Delta\theta \qquad \omega_{avg} = \frac{1}{2}(\omega_o + \omega)$

$\tau = F\,r_{perp} = F\,r\sin\theta$

$\tau_{NET} = \sum\tau = I\,\alpha = m\,r^2\,\alpha$

$KE_{rot} = \frac{1}{2}m\,v^2 + \frac{1}{2}I\,\omega^2$

$L = I\,\omega$

FLUIDS

$\rho = \dfrac{m}{V} \qquad W = mg = \rho V g \qquad \gamma = \rho_{substance} / \rho_{water}$

$P = \dfrac{F}{A} \qquad P = \rho\,g\,h \qquad P = P_{atm} + P_{gage}$

$P = P_o + \rho g h \qquad F_B = \rho_f\,g\,V$

$\rho_1 A_1 v_1 = \rho_2 A_2 v_2$

$P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$

TEMPERATURE

°F = 9/5 °C + 32 $\qquad$ °C = 5/9 (°F – 32) $\qquad$ K = °C + 273.15

$\Delta L = \alpha\,L_o\,\Delta T \qquad \Delta V = \beta\,V_o\,\Delta T$ $\qquad$ *note*: $\beta \cong 3\,\alpha$

GASES

$P\,V = n\,R\,T$ $\qquad$ *R = 8.315 J/mol-K = 0.0821 L-atm/mol-K*

$\dfrac{P_1 V_1}{T_1} = \dfrac{P_2 V_2}{T_2} \qquad N_{avog} = 6.02 \times 10^{23}$ molecules/mole

$KE_{avg} = \frac{1}{2} m v^2 = \dfrac{3}{2} k\,T \qquad k = 1.38 \times 10^{-23}$ J/K

$U = \dfrac{3}{2} N\,k\,T = \dfrac{3}{2} n\,R\,T$

HEAT

$Q = m\,c\,\Delta T \qquad c_{water} = 1.00$ *Kcal/kg°C = 4186 J/kg°C*

$Q_f = m\,L_f \qquad L_{fwater} = 3.33 \times 10^5$ J/kg

$Q_v = m\,L_v \qquad L_{vwater} = 22.6 \times 10^5$ J/kg

$Q_{in} = -Q_{out}$

$\dfrac{\Delta Q}{\Delta t} = k\,A\,\dfrac{T_2 - T_1}{L} \qquad R = \dfrac{L}{k}$

$\dfrac{\Delta Q}{\Delta t} = e\,\sigma\,A\,T^4 \qquad \sigma = 5.67 \times 10^{-8}\ W/m^2K^4$

THERMODYNAMICS

$\Delta U = Q - W$ (*first law*)

Isothermal (*T = constant*): $\Delta U = 0$, $Q = W$

Adiabatic: $Q = 0$

Isobaric (*P = constant*): $W = P\,\Delta V$

Isochoric (*V = constant*): $W = 0$

$e = \dfrac{W}{Q_H} = \dfrac{Q_H - Q_L}{Q_H} = 1 - \dfrac{Q_L}{Q_H}$

$e_{ideal} = \dfrac{T_H - T_L}{T_H} = 1 - \dfrac{T_L}{T_H}$

MISCELLANEOUS

$A_{circle} = \pi\,r^2 \qquad A_{\Delta} = \frac{1}{2}\,b\,h \qquad A_{rectangle} = b\,h$

$V_{box} = l\,w\,h \qquad V_{cylinder} = \pi\,r^2\,h \qquad V_{sphere} = 4/3\,\pi\,r^3$