PHYSICS 101 EQUATION SHEET

Prof. Doney 10/12/16

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 = 1×10^{-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 = 1.013×10^5 N/m^2 = 14.7 psi

$g = 9.8\ m/s^2$ $G = 6.67 \times 10^{-11}\ Nm^2/kg^2$

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)

$x = v_{avg}\, t$ $\Delta x = v_o t + ½ a t^2$

$v = v_o + at$ $v^2 = v_o^2 + 2a\Delta x$

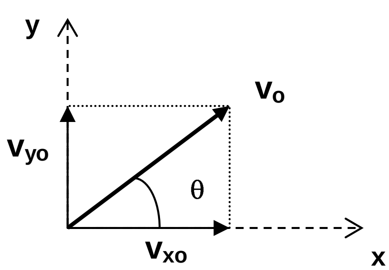
$\overline{v} = ½ (v + v_o)$ $\Delta x = x - x_o$

CONSTANT ACCELERATION (y-dir)

$\Delta y = v_o t + ½ g t^2$ $v = v_o + gt$

$v^2 = v_o^2 + 2g\Delta y$ $\Delta y = y - y_o$

PROJECTILE MOTION (2-D)



x-direction: $a_x = 0$

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

$v_x = v_{xo}$ $\Delta x = v_{xo}\, t$

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

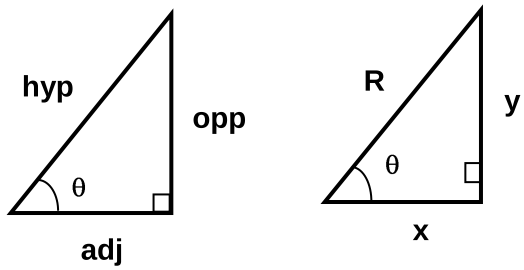
$v_{yo} = v_o \sin\theta$

$\Delta y = v_o t + ½ g t^2$ $v = v_o + gt$

$v^2 = v_o^2 + 2g\Delta y$ $\Delta y = y - y_o$

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*: $a \neq 0$, 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)

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

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

WORK & ENERGY

$W = F_{perp}\, d = (F \cos\theta)\, d$

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

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

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

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

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

ELASTIC: $m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$

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

INELASTIC: $m_1 v_{1i} + m_2 v_{2i} = (m_1 + m_2) v_f$

C.O.M. & MOMENT OF INERTIA

$X_{com} = \frac{\sum m_i x_i}{m_{total}} \qquad Y_{com} = \frac{\sum m_i y_i}{m_{total}}$

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

CIRCULAR MOTION (constant accel)

$360° = 2\pi = 1$ rev. $\qquad s = r\,\Delta\theta$

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

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

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

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

ROTATIONAL MOTION (constant accel)

α = constant $\qquad \theta = ½ (\omega_o + \omega)\, t$

$\Delta\theta = \omega_o t + ½ \alpha t^2 \qquad \omega = \omega_o + \alpha t$

$\omega^2 = \omega_o^2 + 2\alpha\Delta\theta \qquad \omega_{avg} = ½(\omega_o + \omega)$

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

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

$KE_{rot} = ½ m v^2 + ½ I \omega^2$

$L = I\,\omega$

FLUIDS

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

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

$P = P_o + \rho g h \qquad F_B = \rho_f g V \qquad \rho_{water} = 1000\ kg/m^3$

$\rho_1 A_1 v_1 = \rho_2 A_2 v_2$

$P_1 + ½ \rho v_1^2 + \rho g y_1 = P_2 + ½ \rho v_2^2 + \rho g y_2$

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*

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

$KE_{avg} = ½ m v^2 = \frac{3}{2} k T \qquad k = 1.38 \times 10^{-23}\ J/K$

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

HEAT

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

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

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

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

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

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

THERMODYNAMICS

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

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

Adiabatic: $Q = 0$

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

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

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

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

MISCELLANEOUS

$A_{circle} = \pi r^2 \qquad A_{\Delta} = ½ b h \qquad A_{rectangle} = b h$

$V_{box} = l w h \qquad V_{cylinder} = \pi r^2 h$