Equations Sheet

Kinematics

$v = v_0 + at$

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

$\Delta x = v_0 t + \frac{1}{2}at^2$

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

$\Omega = \Omega_0 + \alpha t$

$\Delta\theta = \frac{1}{2}(\Omega_0 + \Omega_f)t = \Omega_{ave}t$

$\Delta\theta = \Omega_0 t + \frac{1}{2}\alpha t^2$

$2\alpha\Delta\theta = \omega_f^2 - \omega_0^2$

Tangential — Rotational

$\Delta S = r\Delta\theta$

$v_{tangential} = r\Omega$

$a_{tangential} = r\alpha$

$a_c = \frac{v^2}{r}$

Rolling

$\Delta S = \Delta x$

$v_{linear} = v_{tangential}$

$a_{tangential} = a_{linear}$

Newton's Laws

$\sum F_x = ma_x$

$\sum F_y = ma_y$

$f_{static}^{max} = \mu_s F_N$

$f_{kinetic} = \mu_k F_N$

Torque

$\boldsymbol{\tau} = \mathbf{I}\boldsymbol{\alpha}$

$\boldsymbol{\tau} = \mathbf{r} \times \mathbf{F}$

$\tau_z = rF_{perpendicular} = rF\sin\varphi = xF_y - yF_x$

Moment of Inertia

$I_{total} = I_1 + I_2 + I_3 + \ldots$

$I = I_{CM} + Md^2$

Work and Energy

$W_{nc} = \Delta K + \Delta U$ $W = F\Delta x\cos(\varphi)$ $K_{linear} = ½mv^2$

$K_{rotational} = ½I\Omega^2$ $U_{gravity} = mgh$ $U_{spring} = ½Kx^2$

Collisions

$\boldsymbol{p} = m\boldsymbol{v}$ $\mathbf{P} = \sum_i \mathbf{p}_i$ $\boldsymbol{P}_f = \boldsymbol{P}_i$ $v_{1f} - v_{2f} = -(v_{1i} - v_{2i})$ $\boldsymbol{I} = \Delta\boldsymbol{P} = \boldsymbol{F}_{average}t$

Angular Momentum

$\boldsymbol{L} = \boldsymbol{r} \times \boldsymbol{p}$ $L_z = xp_y - yp_x = rp\sin\varphi$ $\boldsymbol{L}_{final} = \boldsymbol{L}_{initial}$

$\boldsymbol{L}_{total} = \boldsymbol{L}_1 + \boldsymbol{L}_2 + \ldots$ $L_{linear} = bmv$ $\boldsymbol{L}_{orbital} = r^2m\boldsymbol{\Omega}$ $\boldsymbol{L}_A = \boldsymbol{I}_A\boldsymbol{\Omega}_A$

Simple Harmonic Motion

$x(t) = A\cos(\Omega t + \delta)$ $v(t) = -\Omega A\sin(\Omega t + \delta)$ $a(t) = -\Omega^2A\cos(\Omega t + \delta)$

$\omega = 2\pi f = \frac{2\pi}{T}$ $\omega = \sqrt{\frac{k_{spring}}{m}}$ $T_{pendulum} = 2\pi\sqrt{\frac{L}{g}}$

Waves

$v = \lambda f = \frac{\lambda}{T}$ $v = \sqrt{\frac{F_{Tenion}}{M/L}}$ $y(x,t) = A\sin(kx \mp \omega t)$

Standing Waves

If the string is fixed at both ends or air column is open at both ends

Use $f_n = n\left(\frac{v}{2L}\right), \quad n = 1,2,3,\ldots$

Use $$\lambda_n = \frac{2L}{n}, \quad n = 1,2,3,\ldots$$

If the string or air column has one open end and one fixed end

Use $$f_n = n\left(\frac{v}{4L}\right), \quad n = 1,3,5,\ldots$$

Use $$\lambda_n = \frac{4L}{n}, \quad n = 1,3,5,\ldots$$

$y_n(x,t) = A_n cos(\Omega_n t) sin(k_n t)$ $\quad$ $\Omega_n = 2\pi f_n$ $\quad$ $k_n = \frac{2\pi}{\lambda_n}$

Sound Level / Decibels / Sound Intensity

$I_{total} = I_1 + I_2 + I_3 + \ldots$ $\quad$ $I_{spherical\ source} = \frac{P}{4\pi R^2}$ $\quad$ $\beta = 10\log_{10}\left(\frac{I_{total}}{I_0}\right)$

$I_{total} = I_0 \times 10^{(\beta/10)}$ $\quad$ $I_0 = 1 \times 10^{-12}\ W/m^2$

Doppler Shift

Use $$f_{listener} = f_{source}\left(\frac{1 \pm \frac{v_{receiver}}{v_{sound}}}{1 \mp \frac{v_{source}}{v_{sound}}}\right)$$

+ receiver approaching
− receiver receding
− source approaching
+ source receding

Interference

Constructive interference (maximum amplitude) when $\Delta x = n\lambda$, $n = 1,2,3, \ldots$

Destructive interference (zero or minimum amplitude) when $\Delta x = \frac{1}{2}n\lambda$, $n = 1,3,5, \ldots$

Beats

$f_{beat} = |f_1 - f_2|$

Quadratic Formula

if $ax^2 + bx + c = 0$, then $x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$.

Questions?mike.coombes@kwantlen.ca