AP Physics C: Mechanics Notes

Vector vs. Scalar

Uniformly Accelerated Motion

$\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$

$v_f = v_i + a \Delta t$ $a = \#$

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

$\Delta x = \frac{1}{2}(v_f + v_i)\Delta t$

$a = \frac{dv}{dt} \Rightarrow v = \int a\,dt$

$a = \frac{\Delta v}{\Delta t}$ derivative $\Rightarrow$ slope of the line

$v = \frac{dx}{dt} \Rightarrow x = \int v\,dt$

$v = \frac{\Delta x}{\Delta t}$ Integral $\Rightarrow$ Area "under" the curve

Projectile Motion

x-dir	y-dir
$a_x = 0$	$a_y = -g$
$v_x = \frac{\Delta x}{\Delta t}$	$g = +9.81\ \frac{m}{s^2}$
constant velocity	UAM Freefall

Δt

$\Sigma \vec{F} = m\vec{a}$ Free Body Diagram

on what?

Direction?

Positive Direction?

$\Sigma \vec{F} = \frac{d\vec{p}}{dt} = \frac{d(m\vec{v})}{dt}$

$\Sigma \vec{F} = \frac{dm}{dt} v + m\frac{dv}{dt}$

$J = \int \vec{F}\,dt = \Delta \vec{p}$

$\Sigma \vec{F} = \frac{d\vec{p}}{dt} = 0 \Rightarrow \Sigma \vec{p}_i = \Sigma \vec{p}_f$

$F_f \le \mu F_N \Rightarrow F_{kf} = \mu_k F_N$

$F_{sf} \le \mu_s F_N$ & $F_{sf_{max}} = \mu_s F_N$

- opposes motion
- $\parallel$ to surface
- Independent of F_a

$W = \int \vec{F} \cdot d\vec{r} = \vec{F} \cdot \vec{r} = Fr\cos\theta$

if Constant Force

$KE = \frac{1}{2} m v^2$

$U_g = mgh$

$U_e = \frac{1}{2} k x^2$

$ME_i = ME_f$ (No F_a + No F_f)

$W_f = \Delta ME$ (No F_a)

$W_{net} = \Delta KE$ (Always)

$P = \frac{dW}{dt} = \frac{d\vec{F}\cdot\vec{r}}{dt} = \vec{F}\cdot\vec{v}$

$W = \int P \cdot dt$

$F = -\frac{dU}{dx}$ $F_s = \frac{-dU_s}{dx} = -\frac{d}{dx}\left(\frac{1}{2}kx^2\right)$

$\Rightarrow -\frac{1}{2}k\,2x' = -kx$

(Conservative Force)

$x_{cm} = \frac{m_1 x_1 + m_2 x_2 + \cdots}{m_1 + m_2 + \cdots}$

System of Particles

$r_{cm} = \frac{1}{m}\int \vec{r}\,dm$

Rigid Object w/ Shape

Circular Motion

$\omega = \frac{d\theta}{dt}$ & $\alpha = \frac{d\omega}{dt}$

$a_c = \frac{v_t^2}{r} = r\omega^2$

$s = r\theta$

$v_t = r\omega$

$a_t = r\alpha$

Use Radians

$\tau = \vec{r} \times \vec{F}$

$= \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ r_x & r_y & r_z \\ F_x & F_y & F_z \end{vmatrix}$

$= \vec{r}\vec{F}\sin\theta$

$\Sigma \tau = I\alpha$

AOR?

Object(s)

Direction?

Positive?

Rigid Object w/ shape

$I = \int r^2\,dm$

$I = \Sigma m r^2$

System of Particles

$\rho = \frac{m}{V}$; $\sigma = \frac{m}{A}$; $\lambda = \frac{m}{\lambda}$

$I = I_{cm} + mD^2$

(ρ = constant)

Translational Equilibrium

$\Sigma \vec{F} = 0 \Rightarrow m\vec{a} = 0 \Rightarrow \vec{a} = 0$

Rotational Equilibrium

$\Sigma \tau = 0 \Rightarrow I\alpha = 0 \Rightarrow \alpha = 0$

$KE_{ROT} = \frac{1}{2} I \omega^2$

Rolling w/o Slipping

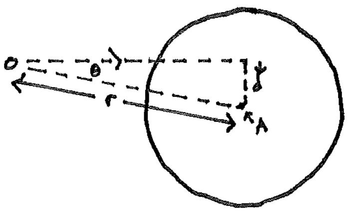
$ME_i = ME_f$

$v_{cm} = r\omega$

$\vec{L}_{(AOR)} = \vec{r} \times \vec{p} = rp\sin\theta$

$= rmv\sin\theta$

(particle)



$L = r \times p = rmv\sin\theta = dmv$

$\sin\theta = \frac{O}{H} = \frac{d}{r}$

$d = r\sin\theta$

Rigid Objects w/ shape

$\vec{L} = I\vec{\omega}$

$\Sigma \tau = \frac{d\vec{L}}{dt} = 0$

AOR

$\Sigma \vec{L}_i = \Sigma \vec{L}_f$

$F_g = -\frac{G m_1 m_2}{r^2}\hat{r}$

Kepler's 3rd Law

$\Sigma F_{in} = F_g = m a_c$

$\Rightarrow \frac{G m_1 m_2}{r^2} = m_1 r\omega^2$

$G m_{planet} = r^3\omega^2$

$\omega = \frac{\Delta\theta}{\Delta t} = \frac{2\pi}{T}$

$G m_{planet} = r^3\left(\frac{2\pi}{T}\right)^2$

$G m_{planet} = \frac{r^3 4\pi^2}{T^2}$

$f = \frac{1}{T}$

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

$U_g = -\frac{G m_1 m_2}{r}$

Z.L. @ $r \approx \infty$

$U_g = 0$

Simple Harmonic Motion (SHM)

$\frac{d^2x}{dt^2} = -\omega^2 x$

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

$\Sigma F_x = -F_s = -kx = ma_x$

$a_x = -\frac{k}{m}x$

$\frac{d^2x}{dt^2} = -\frac{k}{m}x = -\omega^2 x$

$\omega = \sqrt{\frac{k}{m}} = \frac{2\pi}{T} \Rightarrow T = 2\pi\sqrt{\frac{m}{k}}$

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

$E_{tot} = \frac{1}{2}kA^2 = \frac{1}{2}mv_{max}^2$