REVIEW

- SCIENTIFIC NOTATION
- SIG. FIGS.
- UNITS
- CONVERSIONS
- DIMENSIONS
- VECTORS
- COORDINATES

KINEMATICS (MOTION WITHOUT CAUSE)

LINEAR

$\vec{r} = \langle x, y, z \rangle$

$\vec{v} = \langle v_x, v_y, v_z \rangle$

$\vec{a} = \langle a_x, a_y, a_z \rangle$

POSITION $\equiv \vec{r}$

VELOCITY $\equiv \vec{v}$

ACCELERATION $\equiv \vec{a}$

AVG. VELOCITY $\equiv \bar{\vec{v}}$

$\bar{\vec{v}} = \frac{\Delta \vec{r}}{\Delta t}$

AVERAGE ACCEL. $\equiv \bar{\vec{a}}$

$\bar{\vec{a}} = \frac{\Delta \vec{v}}{\Delta t}$

CONST $\vec{a}$

$\Delta \vec{r} = \vec{v}_i \Delta t + \frac{1}{2}\vec{a}\Delta t^2$

$\vec{v}_f = \vec{v}_i + \vec{a}\Delta t$

$v_{f_x}^2 = v_{i_x}^2 + 2a_x \Delta t$

GRAPHS

$x(t) \xrightarrow{\text{SLOPE}} v(t) \xrightarrow{\text{SLOPE}} a(t)$

$a(t) \xrightarrow{\text{AREA}} v(t) \xrightarrow{\text{AREA}} x(t)$

ROTATIONAL

$\vec{v} = \langle v_r, v_t, v_z \rangle$

$\vec{a} = \langle a_r, a_t, a_z \rangle$

CYLINDRICAL FOR r = CONSTANT

ANGULAR POSITION $\equiv \phi$ (RADIANS)

ANGULAR VELOCITY $\equiv \omega$ (RAD/S)

ANGULAR ACCELERATION $\equiv \alpha$ (RAD/S^2)

AVERAGES

$\bar{\omega} = \frac{\Delta \phi}{\Delta t}$

$\bar{\alpha} = \frac{\Delta \omega}{\Delta t}$

CONSTANT α

$\Delta \phi = \omega_i \Delta t + \frac{1}{2}\alpha \Delta t^2$

$\omega_f = \omega_i + \alpha \Delta t$

$\omega_f^2 = \omega_i^2 + 2\alpha \Delta \phi$

GRAPHS

$\phi(t) \xrightarrow{\text{SLOPE}} \omega(t) \xrightarrow{\text{SLOPE}} \alpha(t)$

$\alpha(t) \xrightarrow{\text{AREA}} \omega(t) \xrightarrow{\text{AREA}} \phi(t)$

LINEAR ⟷ ROTATIONAL

ARC LENGTH $\equiv s = r\Delta\phi$

TANGENTIAL VELOCITY $= v_t = \omega r$

TANGENTIAL ACCELERATION $\equiv a_t = \alpha r$

RADIAL ACCELERATION $\equiv a_r = \frac{v_t^2}{r} = \omega^2 r$

ACCELERATION

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

$\Sigma \vec{\tau} = I\vec{\alpha}$

MECHANICS (MOTION WITH CAUSE)

LINEAR (POINT PARTICLE)

LAWS

1) DEFINES INERTIAL REF. FRAME

2) $\Sigma \vec{F}_{\text{EXT ON SYS}} = M_{sys}\vec{a}_{\text{com sys}}$ OR $\vec{F} = \frac{d\vec{p}}{dt}$

3) OBJECTS INTERACT (FORCE PAIRS)

$\vec{F}_{12} = -\vec{F}_{21}$

FRICTION - OPPOSES RELATIVE DIRECTION OF MOTION BETWEEN SURFACES

$|\vec{F}_{12}^{F,S\max}| = \mu_s |\vec{F}_{12}^{N}|$ $\quad$ $|\vec{F}_{12}^{F,K}| = \mu_K |\vec{F}_{12}^{N}|$ = CONSTANT

POINT PARTICLES ROTATING

→ USE CYLINDRICAL $\hat{r}, \hat{t}, \hat{z}$ OR POLAR $\hat{r}, \hat{t}$

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

$= m\left(\frac{v_t^2}{r}\hat{r} + \alpha r\hat{t} + a_z\hat{z}\right)$

TOOLS

→ F.B.D.

→ ROTATE COORDINATE SYSTEM

→ 2nd LAW

(ROTATIONAL RIGID BODY)

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

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

$|\vec{\tau}| = r_\perp |\vec{F}|$

$|\vec{\tau}| = |\vec{r}| F_\perp$

C.W. (−)

C.C.W. (+)

MOMENT OF INERTIA $\equiv I = \Sigma m_i r_i^2$

MASS DENSITY $\equiv \rho = \frac{M}{V}$

COMPOSITE BODY $\rightarrow I = I_1 + I_2 + I_3 + \dots$

2nd LAW: (LAMINAR MOTION) $\Sigma \vec{\tau}_{\text{EXT ON OBJ}} = I_{obj}\vec{\alpha}$ OR $\Sigma \vec{\tau} = \frac{d\vec{L}}{dt}$

CENTER OF MASS

$\vec{r}_{cm} = \frac{\Sigma_i \vec{r}_i m_i}{\Sigma_i m_i}$

TOOLS

→ e. F.B.D.

→ 2nd LAW

$KE_{\text{LINEAR}} = \frac{1}{2}m|\vec{v}|^2$

$KE_{\text{ROTATIONAL}} = \frac{1}{2}I|\vec{\omega}|^2$

MOMENTUM

$\vec{p} = m\vec{v}$

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

(FORCES)·(DIST)

$W = \vec{F}\cdot\Delta\vec{r}$

$W = \tau\Delta\theta$

CONSTANT FORCES AND TORQUES

(FORCE)·(TIME)

$\Delta\vec{p} = \Sigma\vec{F}\Delta t$

$\Delta\vec{L} = \Sigma\vec{\tau}\Delta t$

MOMENTUM

LINEAR

$\vec{p} = m\vec{v}$

MOMENTUM $\equiv \vec{p}$

IMPULSE $\equiv \vec{J}$

$\vec{J} = \Delta\vec{p} = \Sigma\vec{F}_{EXT}\Delta t$

IMPULSE = AREA UNDER F vs t GRAPH

CONSERVATION OF MOMENTUM

IF $\Sigma\vec{F}_{EXT} = \vec{0}$

THEN $\Delta\vec{P}_{sys} = \vec{0}$

THUS $\Sigma\vec{P}_i = \Sigma\vec{P}_f$

NEWTON'S SECOND LAW REVISIT

$\Sigma\vec{F}_{EXT} = \frac{\Delta\vec{P}}{\Delta t}$

ANGULAR

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

ANGULAR MOMENTUM $\equiv L$

ANGULAR IMPULSE $\equiv J$

$J = \Delta L = \Sigma\tau_{EXT}\Delta t$

ANGULAR IMPULSE = AREA UNDER τ vs t GRAPH

CONSERVATION OF ANGULAR MOMENTUM

IF $\Sigma\tau_{EXT} = 0$

THEN $\Delta L_{sys} = 0$

THUS $\Sigma L_i = \Sigma L_f$

ROTATIONAL 2nd LAW REVISIT

$\Sigma\tau_{EXT} = \frac{\Delta L}{\Delta t}$

$KE_{\text{LINEAR}} = \frac{|\vec{p}|^2}{2m}$

$KE_{\text{ROTATIONAL}} = \frac{|\vec{L}|^2}{2I}$

ENERGY

WORK-KINETIC ENERGY THEOREM

$\Sigma KE_i + \Sigma W = \Sigma KE_f$

WORK $\equiv W$

WORK = AREA UNDER F vs x GRAPH

$W = \vec{F}\cdot\Delta\vec{r}$

FOR CONSTANT FORCE

$W = |\vec{F}||\Delta\vec{r}|\cos\theta$

ROTATIONAL ENERGY

$KE = KE_T + KE_R$

$\frac{1}{2}Mv^2$ $\quad$ $\frac{1}{2}I\omega^2$

CONSERVATION OF ENERGY

$\Sigma E_i + \Sigma W_{INT}^{NC} + \Sigma W_{EXT} = \Sigma E_f$

MECHANICAL ENERGY $\equiv E$

$E = KE + U^g + U^s$