(1) MECHANICS

$$v = \frac{\mathrm{d}x}{\mathrm{d}t}$$

$$a = \frac{\mathrm{d}v}{\mathrm{d}t}$$

Where $\bar{v}$ is the average velocity:

$$\bar{v} = \frac{\Delta x}{\Delta t}$$

In a constant acceleration:

$$\begin{aligned} v &= v_0 + at \\ x &= x_0 + v_0 t + \frac{1}{2}at^2 \\ x &= x_0 + \frac{v_0 + v}{2}t \\ ||v|| &= \sqrt{v_0^2 + 2a(x - x_0)} \end{aligned}$$

(2) FORCES

1. A body remains at rest, or in motion at a constant speed in a straight line, unless it is acted upon by a force.
2. $$\sum \vec{F} = m\vec{a}$$
3. If two bodies exert forces $\vec{F}_1, \vec{F}_2$ on each other, then $\vec{F}_1 = -\vec{F}_2$.

$$F_g = mg$$

$$F_{sp} = k\,\Delta\ell$$

$$f_s \leq \mu_s N$$

$$f_k = \mu_k N$$

(3) ENERGY

$$W = \int \vec{F}(s)\,\mathrm{d}s$$

$$\begin{gathered} (\exists c\,\forall x\colon |F(x)| = c) \\ \implies W = F_x \cdot \Delta x = F\cos\theta\Delta s \end{gathered}$$

$$E_k = \frac{1}{2}m\,||v||^2$$

$$U_g = mgh$$

$$U_{sp} = \frac{1}{2}k(\Delta\ell)^2$$

$$E_{k1} + U_{g1} = E_{k2} + U_{g2}$$

$$\forall i, j\colon\ \left(\sum E\right)_i = \left(\sum E\right)_j$$

$$W_F = \Delta E = E_{\text{final}} - E_{\text{begining}}$$

(4) ROTATIONAL MOVEMENT

$$f = \frac{1}{T} \quad [\mathrm{Hz}]$$

$$L = r\psi_{\text{rad}}$$

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

$$v = \frac{2\pi r}{T}$$

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

$$v = \omega r$$

$$a_R = \frac{v^2}{r} = \omega^2 r$$

$$P = 2\pi r$$

Critical Velocity at max.:

$$N = 0 \iff v = \sqrt{gr}$$

$$a_T = -g\sin\alpha$$

$$\vec{a} = \vec{a}_T + \vec{a}_r$$

$$|a| = \sqrt{a_T^2 + a_R^2}$$

$$\tan\theta = \frac{|a_T|}{|a_R|}$$

(5) GRAVITY

For a given gravitational system:

$$\exists c\,\forall i\colon \frac{T_i^2}{r_i^3} = c = \frac{4\pi^2}{GM}$$

$$\left(\frac{\bar{r}_1}{\bar{r}_2}\right)^3 = \left(\frac{T_1}{T_2}\right)^2$$

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

$$U_G = -\frac{GMm}{r}$$

$$E_k = \frac{GMm}{2r} = -\frac{U_G}{2}$$

$$\begin{aligned} \sum E_{\text{mechanic}} &= E_k + U_G \\ &= -\frac{GMm}{2r} = -E_k \end{aligned}$$

$$(W_g)_{A\to B} = GMm\left(\frac{1}{r_A} - \frac{1}{r_B}\right)$$

$$\rho = \frac{m}{v}$$

(6) MOMENTUM

$$\vec{P} = m\vec{v} \quad [N\sec]$$

$$\vec{J} = \vec{F} \cdot \Delta\vec{t} = \int F\,\mathrm{d}t \quad \left[\frac{\mathrm{kg}\,m}{\sec}\right]$$

$$\vec{J}_{\Sigma F} = \sum_{i=1}^{n} \vec{J}_{F_i} = \Delta\vec{P}$$

$$\forall t_1, t_2 \in \mathbb{R}\colon \sum_{i=1}^{n} m_i\vec{v}_i(t_1) = \sum_{i=1}^{n} m_i\vec{v}_i(t_2)$$

In an inelastic collision:

$$Q = \Delta E_k$$

In an elastic collision, where v_i before collision and u_i after it:

$$\vec{v}_1 - \vec{v}_2 = -(\vec{u}_1 - \vec{u}_2)$$

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