

.....(1).....
MECHANICS

$$v = \frac{dx}{dt}$$

$$a = \frac{dv}{dt}$$

Where \bar{v} is the average velocity:

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

In a constant acceleration:

$$v = v_0 + at$$

$$x = x_0 + v_0 t + \frac{1}{2}at^2$$

$$x = x_0 + \frac{v_0 + v}{2}t$$

$$||v|| = \sqrt{v_0^2 + 2a(x - x_0)}$$

.....(2).....
FORCES

$$F_g = mg$$

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

$$f_s \leq \mu_s N$$

$$f_k = \mu_k N$$

Newton's laws:

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 $\vec{F}_1 = -\vec{F}_2$.

.....(3).....
ENERGY

$$W = \int \vec{F}(s) ds$$

$$(\exists c, \theta \forall t: |F(t)| = c, \angle F(t) = \theta)$$

$$\implies W = F_x \cdot \Delta x = F \cos \theta \Delta s$$

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

$$U_g = mgh$$

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

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

$$\forall i, j: (\sum E)_i = (\sum E)_j$$

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

.....(4).....
ROTATIONAL MOVEMENT

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

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

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

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

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

$$v = \omega r$$

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

$$P = 2\pi r$$

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

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

$$F_g = G \frac{Mm}{r^2}$$

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

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

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

In a circular motion:

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

$$\sum E_{\text{mechanic}} = E_k + U_G$$

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

$$T = \frac{2\pi r}{v} = 2\pi \sqrt{\frac{r^3}{GM}}$$

Kepler's laws of planetary motion:

1. The orbit of a planet is an ellipse
2. A line segment joining a planet and the Sun sweeps out equal areas during equal intervals of time.
3. For a given gravitational system:

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

.....(6).....
MOMENTUM

$$\vec{p} = m\vec{v} \quad [N \text{ sec}] \sim \left[\frac{\text{kg } m}{\text{sec}} \right]$$

$$\vec{J} = \int F dt \stackrel{!}{=} \vec{F} \cdot \Delta \vec{t} = |\vec{F}| |\Delta \vec{t}| \cos \theta$$

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

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

In an inelastic collision:

$$Q = \Delta E_k$$

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

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

Elastic Collision iff no loss of kinetic energy, Inelastic iff not ecstatic.

.....(7).....
CONSTANTS

$M [kg]$	$R [m]$	Obj
$5.974 \cdot 10^{24}$	$6.38 \cdot 10^6$	Earth
$1.99 \cdot 10^{30}$	$6.96 \cdot 10^8$	Sun
$7.35 \cdot 10^{22}$	$1.74 \cdot 10^6$	Moon

$$G = 6.67 \cdot 10^{-11} \frac{Nm^2}{kg}$$

Shahar Perets, 2025

Compiled With L^AT_EX and Made Using Free Software