

Physics I: Mechanics — Equation Sheet

Motion Vectors:

displacement $\Delta \vec{r} = (x_2 - x_1)\hat{i} + (y_2 - y_1)\hat{j}$

average velocity $\vec{v}_{av} = \frac{\Delta \vec{r}}{\Delta t}$ instantaneous velocity $\vec{v} = \frac{d\vec{r}}{dt} = v_x\hat{i} + v_y\hat{j}$

average acceleration $\vec{a}_{av} = \frac{\Delta \vec{v}}{\Delta t}$ instantaneous acceleration $\vec{a} = \frac{d\vec{v}}{dt} = a_x\hat{i} + a_y\hat{j}$

Kinematic Equations of Motion:

$$\begin{aligned} x &= x_0 + v_{0x}t + \frac{1}{2}a_x t^2 & y &= y_0 + v_{0y}t + \frac{1}{2}a_y t^2 \\ v_x &= v_{0x} + a_x t & v_y &= v_{0y} + a_y t \\ v_x^2 &= v_{0x}^2 + 2a_x(x - x_0) & v_y^2 &= v_{0y}^2 + 2a_y(y - y_0) \end{aligned}$$

Circular Motion: $a_{centripetal} = \frac{v^2}{r}$

Forces:

$$\sum \vec{F} = m\vec{a} \quad \sum F_x = ma_x \quad \sum F_y = ma_y \quad f_s = \mu_s N \quad f_k = \mu_k N$$

Work and Power:

$$W = \vec{F} \cdot \vec{d} = Fd \cos \phi \quad W = \int_{x_1}^{x_2} F_x dx \quad P = \frac{dW}{dt} \quad P = \vec{F} \cdot \vec{v}$$

Energy

$$W_{net} = \Delta K \quad K = \frac{1}{2}mv^2 \quad U = mgh \quad \text{Springs: } F = -kx \quad U = \frac{1}{2}kx^2$$

conservative forces $W_c = -\Delta U$

work done by friction: $W_{nc} = -f_k d = -\mu_k N d$

$$W_{nc} = \Delta K + \Delta U \quad \text{or} \quad K_i + U_i + W_{nc} = K_f + U_f$$

Center of Mass: $x_{cm} = \frac{1}{M} \sum_{i=1}^n m_i x_i$

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

Impulse $\vec{I} = \Delta \vec{p} \quad I = \int_{t_1}^{t_2} F(t) dt$

Rotational Motion:

angular position θ

angular velocity $\omega = \frac{d\theta}{dt}$

angular acceleration $\alpha = \frac{d\omega}{dt}$

$$\alpha = \text{constant} \begin{cases} \omega = \omega_0 + \alpha t \\ \theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2 \\ \omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0) \end{cases}$$

Relationship between linear and rotational quantities:

$$s = \theta r \quad v = \omega r \quad a_t = \alpha r \quad a_r = \omega^2 r$$

Rotational Inertia: $I = \sum m_i r_i^2$ $I = I_{\text{cm}} + Mh^2$

Torque: $\tau = rF \sin \phi$ $\vec{\tau} = \vec{r} \times \vec{F}$ $\sum \tau = I\alpha$

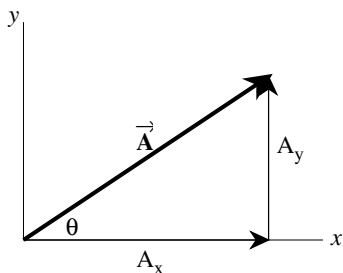
Work, Energy, Power: $W = \int_{\theta_0}^{\theta} \tau d\theta = \Delta K$ $K = \frac{1}{2}I\omega^2$ $P = \frac{dW}{dt} = \tau\omega$

Angular Momentum $L = I\omega$ $\vec{L} = \vec{r} \times \vec{p}$ $\tau = \frac{dL}{dt}$

Gravity $\vec{F}_{12} = -\frac{Gm_1m_2}{r^2}\hat{r}_{21}$ $G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$

MATH HELP

Vectors:



$$A_x = A \cos \theta$$

$$A_y = A \sin \theta$$

$$|\vec{A}| = \sqrt{A_x^2 + A_y^2}$$

$$\theta = \tan^{-1} \left(\frac{A_y}{A_x} \right)$$

Quadratic Equation: $ax^2 + bx + c = 0 \implies x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

CONSTANTS:

$$g = 9.8 \text{ m/s}^2$$