

Formulas PHYS102, Common Exam 2, Spring 2023

Formulas for Motion in 1-dimension

Displacement = $\Delta x = x_2 - x_1$

Average velocity $v_{avg} = \frac{x_2 - x_1}{t_2 - t_1}$

(Average speed) = $s_{avg} = \frac{\text{(Total distance)}}{\text{(Time change)}}$

Average acceleration $a_{avg} = \frac{v_2 - v_1}{t_2 - t_1}$

Motion with a constant velocity, v $x = x_0 + v t$

Motion with a constant acceleration "a"

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

$v^2 - v_0^2 = 2a(x - x_0)$ $x - x_0 = \frac{1}{2} (v_0 + v) t$

Free fall motion:

Motion with a constant acceleration "-g",
where $g = 9.8 \text{ m/s}^2$ (+y direction points up)

$v = v_0 - g t$ $y = y_0 + v_0 t - \frac{1}{2} g t^2$

$v^2 - v_0^2 = -2g(y - y_0)$

Vector Components vs. magnitude and direction

$$\begin{cases} A_x = A \cos(\theta) & (\text{adjacent}) = (\text{hypotenuse}) \times \cos \theta \\ A_y = A \sin(\theta) & (\text{opposite}) = (\text{hypotenuse}) \times \sin \theta \end{cases}$$

$$\begin{cases} |\vec{A}| = \sqrt{(A_x)^2 + (A_y)^2} \\ \theta = \tan^{-1} \left(\frac{A_y}{A_x} \right) = \arctan \left(\frac{A_y}{A_x} \right) \\ \text{(add/subtract 180 deg if necessary)} \end{cases}$$

Equations for Projectile Motion

If the initial velocity $\vec{v}_0 = (v_{0x}, v_{0y})$ $v_{0x} = v_0 \cos \theta_0$
and the initial position $\vec{r}_0 = (x_0, y_0)$ are given, $v_{0y} = v_0 \sin \theta_0$

X-component (horizontal) motion

$v_x = v_{0x}$

$x = x_0 + v_{0x} t$

Range: $(v_0^2/g) * \sin(2\theta)$

Y-component (vertical) motion
(+y direction points up)

$v_y = v_{0y} - g t$

$y = y_0 + v_{0y} t - \frac{1}{2} g t^2$

$v_y^2 - v_{0y}^2 = -2g(y - y_0)$

$\Delta y = \left(\frac{v_{0y} + v_y}{2} \right) \cdot t$

Units:

$1 \text{ cm} = 10^{-2} \text{ m}$; $1 \text{ km} = 1000 \text{ m}$

$1 \text{ g} = 10^{-3} \text{ kg}$

$1 \text{ lt} = 1000 \text{ ml}$; $1000 \text{ lt} = 1 \text{ m}^3$

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Newton's 2nd law: $\vec{F}_{net} = m\vec{a}$

Static friction : $|\vec{f}_S| < |\vec{f}_S^{Max}| = \mu_S |\vec{F}_N|$

Kinetic friction : $|\vec{f}_k| = \mu_k |\vec{F}_N|$

\vec{F}_N = (normal force)

- Work-Energy Theorem:

$$W_{net} = K_f - K_i$$

$$K = \frac{1}{2}mv^2$$

In 1D, $W_F = F\Delta x$

In 2D, $W_F = |\vec{F}||\vec{d}|\cos\theta_{F,d}$
 $\equiv \vec{F} \cdot \vec{d} = F_x d_x + F_y d_y$

Uniform circular motion

$$\left| \left(\sum \vec{F} \right)_R \right| = m |\vec{a}_R|$$

$$|\vec{a}_R| = \frac{v^2}{r}$$