Formulas PHYS102, Common Exam 2, Fall 2024

Formulas for Motion in 1-dimension

Displacement = $\Delta x = x_2 - x_1$

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

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

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

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

Motion with a constant acceleration "a"

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

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

Free fall motion:
Motion with a constant acceleration "-g",
where g = 9.8 m/s² (+y direction points up)

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

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

Vector Components vs. magnitude and direction

$$\begin{cases} A_x = A\cos(\theta) \\ A_y = A\sin(\theta) \end{cases}$$

$(adjacent) = (hypotenuse) \times \cos\theta$

$(opposite) = (hypotenuse) \times \sin\theta$

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

Equations for Projectile Motion

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

$$v_{0x} = v_0 \cos\theta_0$$
$$v_{0y} = v_0 \sin\theta_0$$

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)

$$v_y = v_{0y} - gt$$
$$y = y_0 + v_{0y} t - \frac{1}{2} g t^2$$
$$v_y^2 - v_{0y}^2 = -2g(y - y_0)$$
$$\Delta y = \left(\frac{v_{0y} + v_y}{2}\right) \cdot t$$

Units:

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

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

1 lt =1000ml; 1000 lt =1m³

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

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

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

$\vec{F}_N$ = (normal force)

Uniform circular motion

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

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

- Work-Energy Theorem:

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

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

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

In 2D, $W_F = \left|\vec{F}\right|\left|\vec{d}\right|\cos\theta_{F,d}$

$$\equiv \vec{F}\cdot\vec{d} = F_x d_x + F_y d_y$$