

Physics Booklet

Iago Mendes

Contents

1	Classical Mechanics	3
1.1	Kinematics	3
1.1.1	Basic concepts	3
1.1.2	Constant acceleration cases (theorems)	3
1.1.3	Uniform circular motion	4
1.2	Forces	4
1.3	Energy	4
1.4	Momentum	4
1.5	Angular momentum	4
1.6	Lagrangian method	4
2	Relativistic Mechanics	5
3	Electromagnetism	6
4	Thermodynamics	7
5	Statistical mechanics	8
6	Quantum mechanics	9

Classical Mechanics

1.1 Kinematics

1.1.1 Basic concepts

- Velocity

$$\vec{v}(t) = \frac{d\vec{r}}{dt}$$

$\vec{r}(t)$: position

- Speed

$$v = |\vec{v}| = \left| \frac{d\vec{r}}{dt} \right|$$

- Acceleration

$$\vec{a}(t) = \frac{d\vec{v}}{dt}$$

- Other rates

– Jerk

$$\vec{j}(t) = \frac{d\vec{a}}{dt}$$

– Snap

$$\vec{s}(t) = \frac{d\vec{j}}{dt}$$

– Crackle

$$\vec{c}(t) = \frac{d\vec{s}}{dt}$$

– Pop

$$\vec{p}(t) = \frac{d\vec{c}}{dt}$$

1.1.2 Constant acceleration cases (theorems)

1. $v(t) = v_0 + at$

$$a = \frac{dv}{dt} \quad \therefore \quad \int_{t_0}^t a dt = \int_{t_0}^t \frac{dv}{dt} dt$$

$$\therefore \quad a \cdot (t - t_0) = [v(t)]_{t_0}^t \quad \therefore \quad v(t) = v_0 + at$$

2. $x(t) = x_0 + v_0 t + \frac{at^2}{2}$

$$v(t) = v_0 + at \quad \therefore \quad \int_{t_0}^t v(t) dt = \int_{t_0}^t (v_0 + at) dt$$

$$\therefore \quad x(t) = x_0 + v_0 t + \frac{at^2}{2}$$

$$3. x(t) = x_0 + vt - \frac{at^2}{2}$$

$$v = v_0 + at \quad \therefore \quad v_0 = v - at$$

$$\therefore x(t) = x_0 + (v - at)t + \frac{at^2}{2} \quad \therefore \quad x(t) = x_0 + vt - \frac{at^2}{2}$$

$$4. x(t) = x_0 + \frac{(v_0+v)t}{2}$$

$$2x = x(t) + x(t) = \left(x_0 + v_0t + \frac{at^2}{2}\right) + \left(x_0 + vt - \frac{at^2}{2}\right)$$

$$\therefore 2x = 2x_0 + v_0t + vt \quad \therefore \quad x(t) = x_0 + \frac{(v_0+v)t}{2}$$

$$5. v^2 = v_0^2 + 2a(x - x_0)$$

$$\begin{cases} v(t) = v_0 + at \\ x(t) = x_0 + \frac{(v_0+v)t}{2} \end{cases} \quad \therefore \quad \begin{cases} v - v_0 = at \\ v + v_0 = \frac{2(x-x_0)}{t} \end{cases}$$

$$\therefore v^2 = v_0^2 + 2a(x - x_0)$$

1.1.3 Uniform circular motion

- Angular velocity

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

- Position

$$\vec{r}(t) = R \cos(\omega t) \hat{i} + R \sin(\omega t) \hat{j}$$

- Velocity

$$\vec{v}(t) = -\omega R \sin(\omega t) \hat{i} + \omega R \cos(\omega t) \hat{j}$$

- Speed

$$v = \omega R$$

- Centripetal acceleration

$$\vec{a} = -\omega^2 \vec{r}$$

$$a = \omega^2 R = \frac{v^2}{R}$$

1.2 Forces

1.3 Energy

1.4 Momentum

1.5 Angular momentum

1.6 Lagrangian method

Relativistic Mechanics

Electromagnetism

Thermodynamics

Statistical mechanics

Quantum mechanics