Classical Mechanics

from the context of the course
PHY 321: Classical Mechanics 1

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Chapter 1

Standard Units

In physics it's often important to have precisely defined units for the purposes of making very accurate measurements or simply having a coherent unit system. It's possible to derive all necessary units from five measurements of **length, mass, time, current, and temperature**. The standard SI units for these properties are listed bellow:

Type	Unit	Definition
Length	Meter(m)	Length of distance light in a vacuum travels in $\frac{1}{299792458}$ seconds
Mass	Kilogram(kg)	Defined by fixing the Planck's constant $h = 6.62607015 \times 10^{-34} kg\ m^2 s^{-1}$
Time	Second(s)	Defined by fixing the ground-state hyperfine transition frequency of the caesium-133 atom, to be $9192631770 s^{-1}$
Current	Ampere(A)	Defined by fixing the charge of an electron as $1.602176634 \times 10^{-19} A \cdot s$
Temperature	Kelvin(K)	Defined by fixing the value of the Boltzmann constant k to $1.380649 \times 10^{-23} kg \cdot m^2 s^{-2} K^{-1}$

Common prefixes are listed bellow:

Prefix	Symbol	Definition
mega	M	10^6
kilo	k	10^3
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}

Chapter 2

Introduction

2.1 Notation

2.2 2d Numerical Motion

Example. Let's consider a 2d system with gravity and air resistance.

$$\mathbf{v} = (v_x, v_y)$$

We define initial condition when $t = 0$

$$v_x(0) = v_{0x}$$
$$v_y(0) = v_{0y}$$
$$\mathbf{F} = -m\gamma\mathbf{v}(t) - mg\mathbf{j}$$

Now applying $\mathbf{F} = m\mathbf{a}$ we find that

$$\mathbf{a} = -\gamma\mathbf{v}(t) - g\mathbf{j}$$
$$a_x = -\gamma v_x(t)$$
$$a_y = -\gamma v_y(t) - g$$

First, lets solve for the x-component:

$$\frac{dv_x}{dt} = -\gamma v_x$$
$$\int \frac{dv_x}{v_x} = \int -\gamma dt$$
$$\ln \frac{v_x}{v_{0x}} = -\gamma t$$
$$v_x(t) = v_{0x}e^{-\gamma t}$$
$$x(t) = x_0 + \frac{v_{0x}}{\gamma}(1 - e^{-\gamma t})$$

Now, lets solve for the y-component:

$$\frac{dv_y}{dt} = -\gamma v_y - g$$
$$\int \frac{dv_y}{v_y - \frac{g}{\gamma}} = \int -\gamma dt$$
$$\ln \frac{v_y - \frac{g}{\gamma}}{v_{y0} - \frac{g}{\gamma}} = -\gamma t$$
$$v_y(t) = (v_{y0} - \frac{g}{\gamma})e^{-\gamma t} + g\gamma$$
$$y(t) = y_0 - g\frac{t}{\gamma} + (v_{oy} + \frac{g}{\gamma})(1 - e^{-\gamma t})\frac{1}{\gamma}$$

2.2.1 Earth Sun Gravitational System

$$\mathbf{F} = G\frac{m_1 m_2 \mathbf{r}}{\mathbf{r}^3}$$
$$\mathbf{r} = \sqrt{x^2 + y^2}$$