Lecture 2: Motion in one dimension

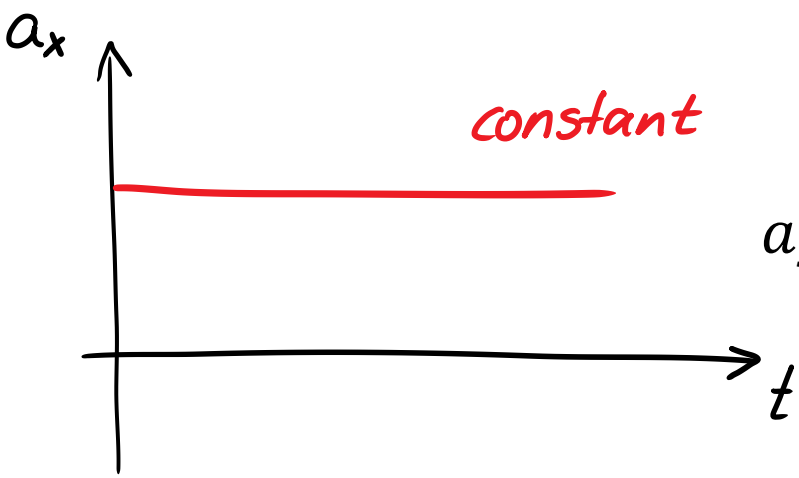
- Motion in one dimension, continued
- Equations for constant acceleration
- Free fall
- Problem solving

Velocity and acceleration

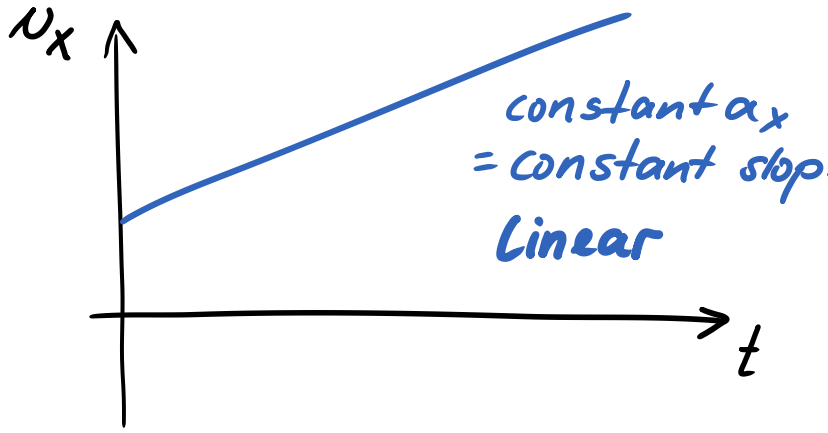
$$v_x = \frac{dx}{dt}$$

$$a_x = \frac{dv_x}{dt} = \frac{d^2x}{dt^2}$$

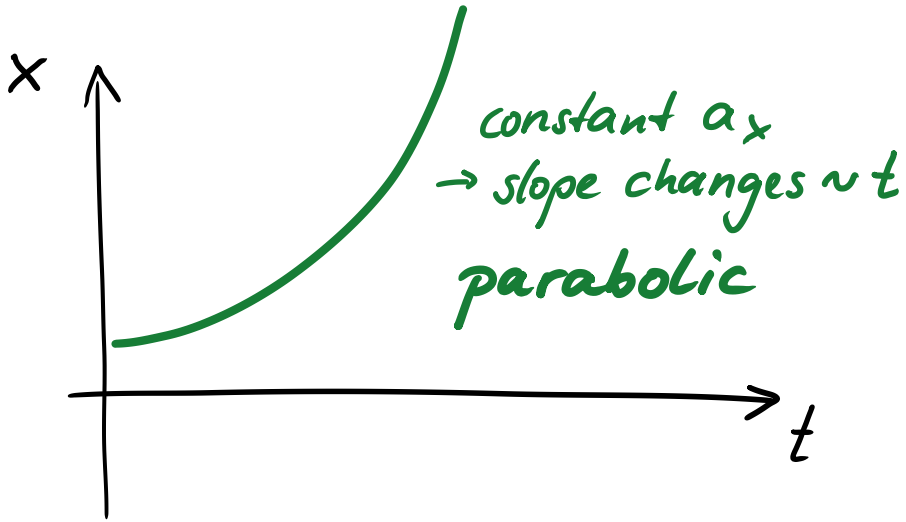
Constant acceleration



$$a_x = \frac{dv_x}{dt}$$



$$v_x = \frac{dx}{dt}$$



Constant acceleration

$$a_x = \frac{dv_x}{dt}$$

$$dv_x = a_x dt$$

$$\int_{v_{0x}}^{v_x(t)} dv_x = \int_{t_0}^{t} a_x dt = a_x \int_{t_0}^{t} dt = a_x(t - t_0)$$

$$v_x - v_{0x} = a_x(t - t_0) = a_x t \text{ with } t_0 = 0$$

$v_x = v_{0x} + a_x t$ and similarly $x = x_0 + v_{0x}t + \frac{1}{2}a_x t^2$

Another useful equation: $v_x^2 = v_{0x}^2 + 2a_x(x - x_0)$

Constant acceleration

starting equations:

$$x = x_0 + v_{0x}t + \tfrac{1}{2}a_x t^2$$

$$y = y_0 + v_{0y}t + \tfrac{1}{2}a_y t^2$$

$$v_x = v_{0x} + a_x t$$

$$v_y = v_{0y} + a_y t$$

$$v_x^2 = v_{0x}^2 + 2a_x(x - x_0)$$

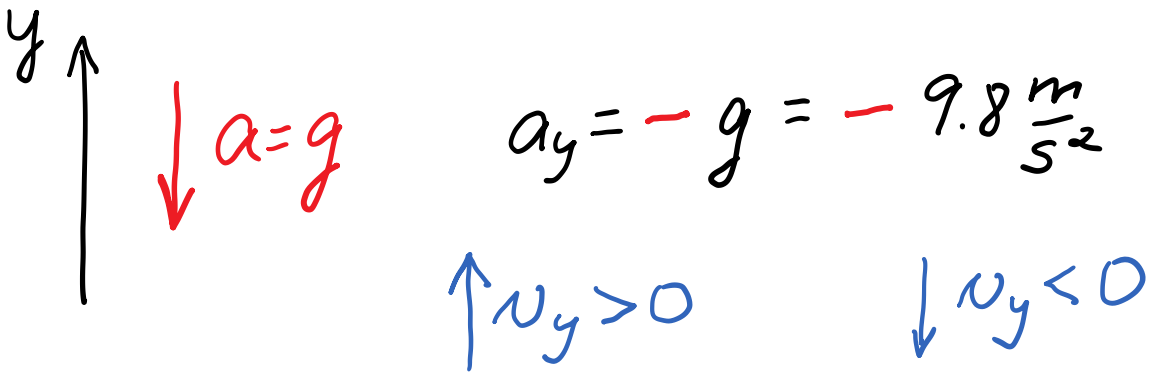
$$v_y^2 = v_{0y}^2 + 2a_y(y - y_0)$$

You will find these equations on the starting equation sheet.
They are your starting point for homework and test problems.

Free fall

Object in free fall experiences a constant downward acceleration of magnitude

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



In absence of air resistance, objects fall with the same acceleration irrespective of mass.

Video: Apollo 15 Feather and Hammer

Example

A person stands on top of a building of height 80m. They throw a ball straight up with an initial speed 20 m/s so that is just misses the edge of the building in coming down. (Use g=10 m/s^2.)*

*Only for this example so that we do not have to use a calculator. On your homework problems, you need to use the more accurate value of 9.8 m/s^2.

Calculate:

a) the time it takes for the ball to reach its highest point

b) the height of the highest point above the ground.

c) the velocity with which the ball hits the ground

To be worked out on the board…

Summary of *Litany for kinematics problems*

1. Complete diagram.
- Draw initial velocity and acceleration
- Draw axis, including origin
- Indicate and label initial and final positions

2. Starting equation

3. Replace generic quantities with information given in the problem

4. Derive symbolic answer
5. Calculate numerical answer (carry units!)