Phys 111 2023

Lecture 10

Weds: Warm Up 4 (D2L)

Thurs: HW 5pm

Ex 72, 82, 87, 89, 93, 94, 99, 100

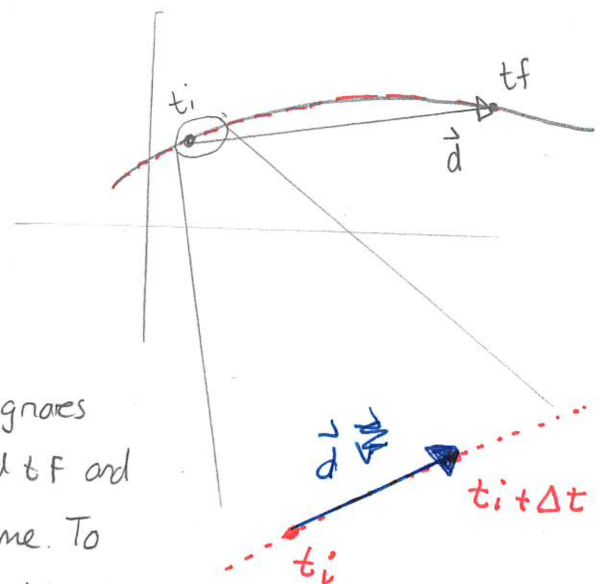
Prev: Defined average velocity vector

Today: Velocity vector, acceleration, projectiles.

Velocity

The average velocity describes the rate at which position changes over an inverval from time t_i to t_f as

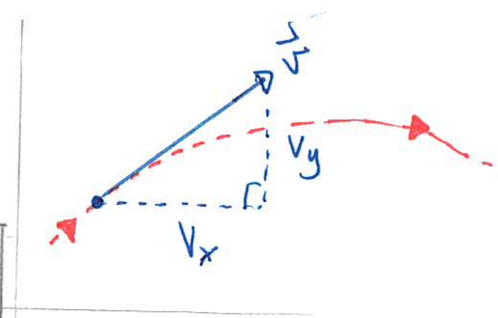
$$\vec{v}_{avg} = \frac{\vec{d}}{\Delta t}$$



The average velocity is a vector. It ignores the details of the motion between t_i and t_f and cannot describe the velocity at a given time. To do this we consider a very small time interval from t_i to $t_i + \Delta t$ where Δt is very small. We can recalculate the average velocity over this interval. Take $\Delta t \to 0$ gives a velocity at t_i

The velocity at t_i is

$$\vec{v} = \lim_{\Delta t \to 0} \frac{\vec{d}}{\Delta t}$$



The instantaneous velocity is a vector

1) direction of velocity is tangent to the trajectory (along direction of motion)

2) the magnitude of velocity is the speed

DEMO: PhET Ladybug → Show velocity vector
→ Show trace = line
→ Use ellipse.

Quiz 1 40% – 90%

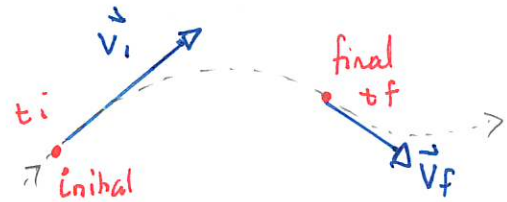
Since velocity is a vector it has components v_x, v_y and the speed is

$$v = \sqrt{v_x^2 + v_y^2}$$

Quiz 2 10% – 50%

Acceleration

Again acceleration is the rate of change of velocity.



The average acceleration from time t_i to t_f is

$$\vec{a}_{avg} = \frac{\vec{v}_f - \vec{v}_i}{t_f - t_i} = \frac{\Delta \vec{v}}{\Delta t}.$$

This requires vector subtraction.

Quiz 3 5% – 90%

Quiz 4

In general acceleration is a vector with components

units: m/s^2

Projectile Motion

A projectile is an object that moves only under the influence of Earth's gravity. Observations about this give:

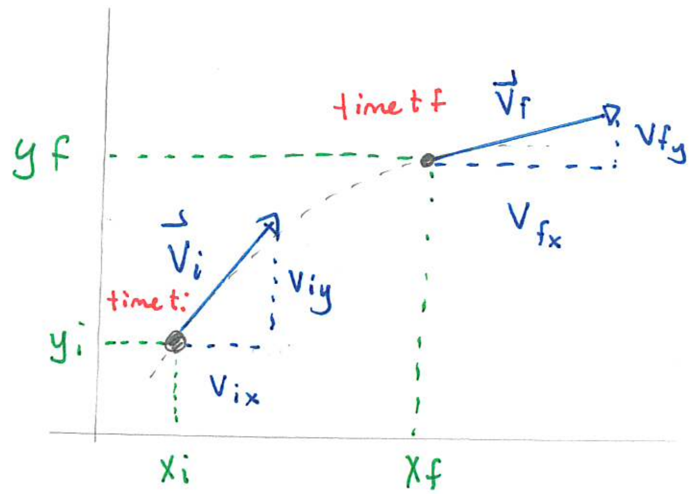
1) The horizontal and vertical components of the motion are independent
2) The acceleration is constant with components

$$a_x = 0\,m/s^2$$
$$a_y = -g = -9.80\,m/s^2$$

$\vec{a}$

DEMO: Ball launched / dropped.

There is a double set of kinematic equations connecting variables at two instants



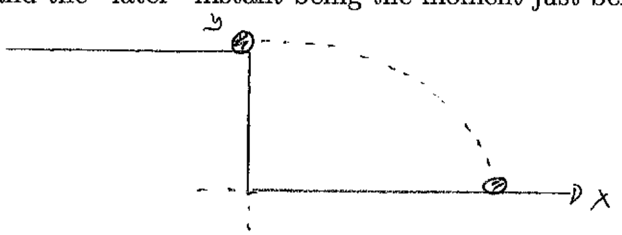
Horizontal	Vertical
$V_{fx} = V_{ix} + a_x \Delta t$	$V_{fy} = V_{iy} + a_y \Delta t$
$x_f = x_i + V_{ix}\Delta t + \frac{1}{2} a_x (\Delta t)^2$	$y_f = y_i + V_{iy}\Delta t + \frac{1}{2} a_y (\Delta t)^2$
$V_{fx}^2 = V_{ix}^2 + 2a_x(x_f - x_i)$	$V_{fy}^2 = V_{iy}^2 + 2a_y(y_f - y_i)$
only horiz.	only vert.

where $\Delta t = t_f - t_i$

91 Running off a roof

A person runs with speed 8.0 m/s off a flat roof that is 3.0 m above the ground. First suppose that the person travels horizontally at the moment that he leaves the roof. Determine how far horizontally from the edge of the roof the person will land. *(111F2023)*

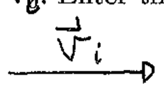
a) Sketch the situation with the "earlier" instant being that at which the person leaves the roof and the "later" instant being the moment just before the person hits the ground.



List as many of the variables as possible. Use the format:

$t_i =$ 0s	$t_f =$
$x_i =$ 0m	$x_f =$
$y_i =$ 3.0m	$y_f =$ 0.0m
$v_{ix} =$ 8.0m/s	$v_{fx} =$ 0 m/s.
$v_{iy} =$	$v_{fy} =$
$a_x =$ 0m/s^2	$a_y =$ −9.80 m/s^2

b) Sketch the velocity vector at the earlier moment and use this to determine the components of $\vec{v}_i$. Enter these in the list above.



$V_{ix} = 8.0 m/s$ $\quad$ $V_{iy} = 0 m/s$

c) Identify the variable needed to answer the question of the problem. Select and write down a kinematic equation that contains this variable and attempt to solve it.

Need x_f

$$x_f = \cancel{x_i}^{0} + V_{ix}\,\Delta t + \tfrac{1}{2}\cancel{a_x}^{0}(\Delta t)^2$$

$x_f = V_{ix}\,\Delta t$ $\quad$ need Δt. or t_f

You should see to solve the variable describing the horizontal position, you first need the value for another, currently unknown variable. Which variable is this?

d) Use the vertical aspects of the object's motion to solve for this other unknown variable and use this result to answer the question of this problem.

$$y_f = y_i + v_{iy}\,\Delta t + \tfrac{1}{2}a_y(\Delta t)^2$$

$$0\,m = 3\,m + \cancel{0\,m/s\,\Delta t} - \tfrac{1}{2}(9.80\,m/s^2)(\Delta t)^2$$

$$\Rightarrow -3\,m = -4.9\,m/s^2\,(\Delta t)^2$$

$$\Rightarrow \frac{-3\,m}{-4.9\,m/s^2} = (\Delta t)^2$$

$$\Rightarrow (\Delta t)^2 = 0.61\,s^2$$

$$\Rightarrow \Delta t = \sqrt{0.61\,s^2} = 0.78\,s$$

Then

$$x_f = v_{ix}\,\Delta t$$

$$= 8.0\,m/s \times 0.78\,s = 6.3\,m$$

Suppose that the person ran and jumped from the building at an angle of 30° above the horizontal. This will change how far the person travels. Before answering that question, we ask, what is the maximum height above the ground reached by the person for this running jump?

e) Sketch the velocity vector at the earlier moment and use this to determine the components of $\vec{v}_0$. Reconstruct the list of variables for the problem.

f) Sketch the velocity vector at the instant when the person reaches his highest point. Use this to add additional information to the list of variables for the problem.

g) Use the kinematic equations to determine the maximum height that the person reaches.