Mon: Warm Up 3 (D2L) by 9am

Tues: Discussion / quiz

Ex: 58, 59, 60, 62, 63, 66, 67

Free fall motion

Free fall is motion where the only influence on an object's motion is Earth's gravity. In general observations show that in free fall:

1) acceleration is non-zero
2) acceleration is independent of the object's state of motion.

Quiz 1 80% - same
Quiz 2 60% - 70%

3) near Earth's surface, the acceleration is constant and

$$\boxed{a = -g \quad \text{where} \quad \underbrace{g = 9.80\,m/s^2}_{\text{this is always positive}}}$$

this makes acceleration negative

The kinematic equations can be adapted for free fall motion and give

$$v_f = v_i + a\Delta t$$
$$y_f = y_i + v_{iy}\Delta t + \tfrac{1}{2}a(\Delta t)^2$$
$$v_f^2 = v_i^2 + 2a(y_f - y_i)$$

$$a = -9.8\,m/s^2 = -g$$

Note that y increases in the upward direction.

Phys 131
Spring 2025

Fundamental Mechanics: Group Exercise 2

31 January 2025

Names: ________________ ________________ ________________

________________ ________________

1 Rock launch speed

A person, lying on their back, throws a rock vertically from the ground. The rock reaches a maximum height of 3.6 m above the ground (about 12 ft). We aim to determine the launch speed and the time of flight of the rock.

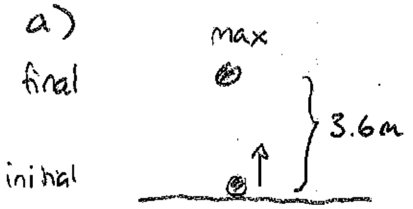
a) First consider the launch speed. Sketch the situation, illustrating the rock at two key instants. List all relevant variables at these instants.

b) Determine the launch speed of the rock.

c) Now consider the time of flight. Again sketch the situation, illustrating the rock at two key instants. List all relevant variables at these instants. Find teh time of flight.

Answer:

a)



$t_i = 0\,s \quad t_f = ?$

$y_i = 0\,m \quad y_f = 3.6\,m \qquad a = -9.8\,m/s^2$

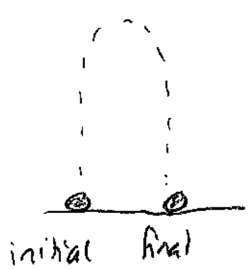
$v_i = ? \quad v_f = 0\,m/s$

b) $v_f^2 = v_i^2 + 2a(y_f - y_i) \Rightarrow (0\,m/s)^2 = v_i^2 + 2(-9.8\,m/s^2)(3.6\,m - 0\,m)$

$\Rightarrow 0\,m^2/s^2 = v_i^2 - 70.6\,m^2/s^2$

$\Rightarrow v_i^2 = 70.6\,m^2/s^2 \Rightarrow v_i = \sqrt{70.6\,m^2/s^2} = 8.4\,m/s$

c)



$t_i = 0\,s \quad t_f = ?$

$y_i = 0\,m \quad y_f = 0\,m$

$v_i = 8.4\,m/s \quad v_f = ?$

$\Rightarrow \cancel{y_f} = \cancel{y_i} + v_i \Delta t + \frac{1}{2} a \Delta t^2$

$\Rightarrow 0 = (v_i + \frac{1}{2} a \Delta t)\Delta t$

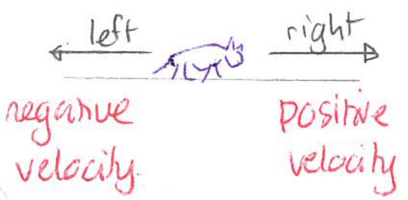
$\Rightarrow \Delta t = 0$ or $v_i + \frac{1}{2} a \Delta t = 0$

$\Rightarrow \Delta t = -\frac{2v_i}{a} = \frac{-2 \times 8.4\,m/s}{-9.8\,m/s^2} = 1.7\,s$

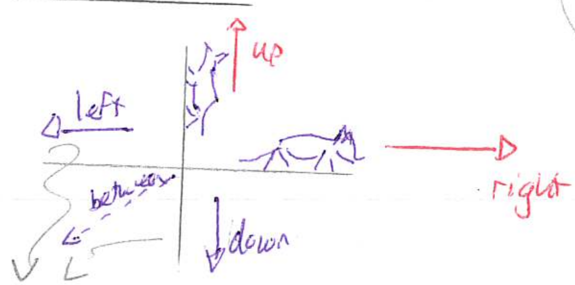
Motion in two dimensions

In general objects can move in two or three spatial dimensions and we must adopt kinematics to these situations, where there are infinitely many directions. Difficulties with this are illustrated below:

One dimension



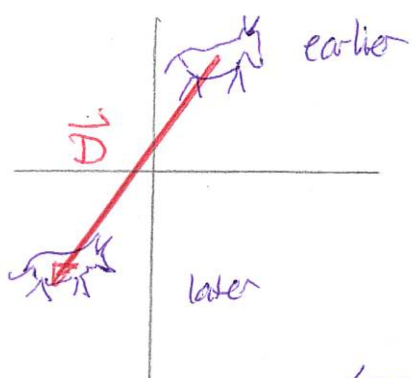
Two dimensions



Saying these are both negative does not differentiate between them. We need more than just negative

We start with displacement which can be described by

> A <u>displacement vector</u> describes a change in position and is one arrow with:
> 1) tail at earlier position
> 2) head at later position



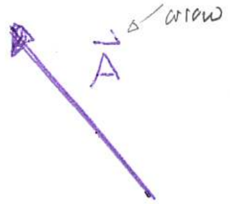
Displacement vectors are denoted by symbols such as $\vec{D}$ — arrow (means vector); label (helps describe which vector)

Displacement vectors contain two pieces of information:

1) magnitude ~ straight line distance from earlier to later point
2) direction.

Again the scheme is:

vector



has size and direction

mathematical ingredients/notation

1) magnitude of a vector

= size of vector, A (no arrow)

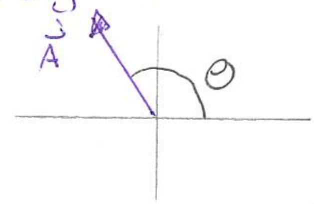
For a displacement vector this is straight line length in meters

never negative

2) direction of a vector

= some description of which way it points

e.g. angle from +x axis



We now want algebraic rules for manipulating vectors. The branch of mathematics that deals with this is linear algebra.

First, equality of vectors

Two vectors $\vec{A}$ and $\vec{B}$ are equal, i.e. $\vec{A}=\vec{B}$	$\Longleftrightarrow$	1) $\vec{A}$ and $\vec{B}$ have the same magnitude AND 2) $\vec{A}$ and $\vec{B}$ have the same direction

Quiz 3