Mon: Warm Up 3 (D2L) by 9am

Tues: ~~Ex~~ Discussion /quiz

Ex:

Free fall motion

Free fall is motion where the only influence on the object is Earth's gravity. An object that undergoes free-fall motion has:

1) non-zero acceleration
2) acceleration which is independent of the object or its state of motion

Quiz 1 80% → 100% ≥ 70% –

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

$$a = -g \quad \text{where} \quad g = 9.80\,m/s^2$$

ALWAYS POSITIVE

For free fall motion we can use kinematic equations with the variable y representing vertical position (increasing upwards):

$$v_f = v_i + a\Delta t$$

$$y_f = y_i + v_i\Delta t + \tfrac{1}{2}a\Delta t^2$$

$$v_f^2 = v_i^2 + 2a(y_f - y_i)$$

$a = -g$

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

Phys 131
Fall 2024

Fundamental Mechanics: Group Exercise 2

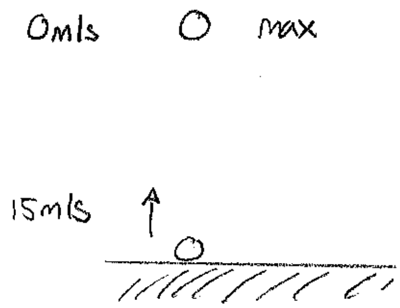
29 August 2024

Names: SOLUTION ____________ ____________ ____________ ____________

1 Ball launched vertically

A ball is launched vertically from Earth's surface with speed 15.0 m/s. The aim of the first part of this exercise is to determine the maximum height reached by the ball.

a) Sketch the situation, illustrating the ball at two key instants. List all relevant variables, including the acceleration, for the two instants.



$t_i = 0.00\,s$ $\quad t_f =$

$y_i = 0.00\,m$ $\quad y_f =$

$v_i = 15.0\,m/s$ $\quad v_f = 0.00\,m/s$

b) Determine the maximum height reached by the ball by using one of the kinematic equations. Write down the equation, substitute from your list of variables and solve for the maximum height variable.

$$v_f^2 = v_i^2 + 2a(y_f - y_i)$$

$$\frac{v_f^2 - v_i^2}{2a} = y_f - \cancel{y_i}$$

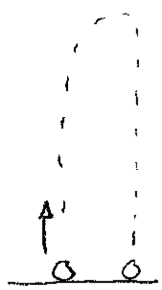
$$\frac{v_f^2 - v_i^2}{-2g} = y_f$$

$$y_f = \frac{(0\,m/s)^2 - (15.0\,m/s)^2}{-2(9.80\,m/s^2)}$$

$$= 11.5\,m$$

The second part of this exercise aims to find the time between launch and when the ball returns to the ground (time-of-flight).

c) Sketch the situation, illustrating the ball at two key instants. List all relevant variables, including the acceleration, for the two instants.



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

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

$V_i = 15.0\,m/s$ $\quad V_f = 0$

$a = -g = -9.80\,m/s^2$

d) Determine time-of-flight of the ball.

$$y_f = y_i + V_i \Delta t + \frac{1}{2} a \Delta t^2$$

$$\Rightarrow \quad 0 = V_i \Delta t - \frac{1}{2} g (\Delta t)^2$$

$$= \Delta t \left(V_i - \frac{1}{2} g \Delta t \right) = 0$$

$\Rightarrow \Delta t = 0$ or

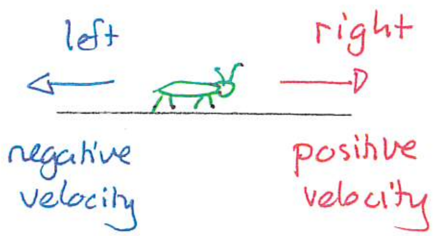
$$V_i - \frac{1}{2} g \Delta t = 0 \quad \Rightarrow \quad \frac{2V_i}{g} = \Delta t \quad \Rightarrow \quad \Delta t = \frac{2 \times 15.0\,m/s}{9.80\,m/s^2}$$

$$\Rightarrow \Delta t = 3.06\,s$$

Motion in Two Dimensions

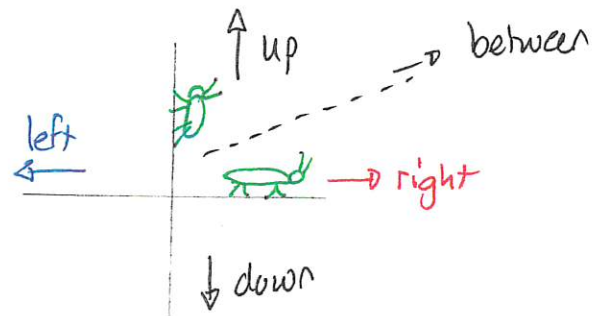
Many objects move in more than one dimension. This will require expanding the kinematical description of an object's motion. The key difference will be the multitude of possible directions.

One dimension



since there are only two distinct directions we can use positive or negative

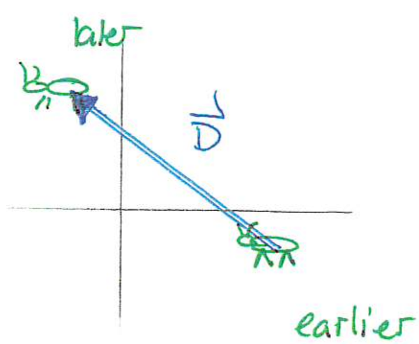
Two dimensions



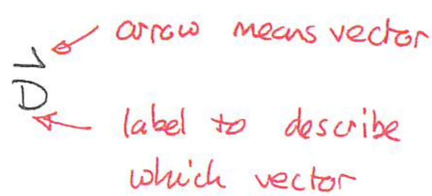
There are infinitely many directions and positive vs negative are not sufficient to characterize them all.

We return to the idea of displacement. This can be generally be described by:

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



We will denote such displacement vectors as $\vec{D}$ and they contain two pieces of information.



1) magnitude
2) direction

vector

has size and direction

mathematical description

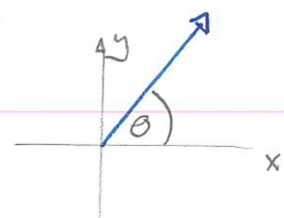
1) magnitude of vector = size of vector

For a displacement vector this is length in meters

magnitude is never negative

2) direction of vector = some description of which way it points

For a displacement vector angle from +x axis



We need algebraic rules for manipulating these vectors

LINEAR ALGEBRA

First:

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

Quiz 2 90%

60% – 95%