Any problem involving dropping or throwing objects, whether they go up or down, is just what we call a "Free Fall" problem. Free fall just means that the only acceleration is gravity, so on the earth that means

$$a = -10 \ m/s^2$$

This also means that free fall problems are just constant acceleration problems. However, you happen to know a few things.

EQUATIONS

$$y = \frac{1}{2}at^2 + v_i t$$

$$v_f = at + v_i$$

$$y = \bar{v} t$$

$$\bar{v} = \frac{v_i + v_f}{2}$$

THINGS YOU KNOW

- $a = -10 \ m/s^2$
- $v = 0 \ m/s$ @ the maximum height
- If initial height = final height then $t_{up} = t_{down}$ (or time to max height $= \frac{1}{2}$ total time)

Any quantity going up is +

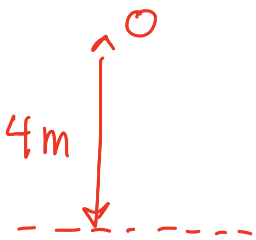
Any quantity going down is −

Sample 1

A ball is dropped from a height of 4 m.

a) How long will it take to fall?

b) What is its velocity just as it hits the ground?



Givens/things we know:

$v_i = 0$ m/s (because it was dropped)

$a = -10$ m/s² (because its gravity)

$y = -4$ m (because it went down)

So for part a)

$$y = \frac{1}{2}at^2 + v_i t$$

$$-4 = \frac{1}{2}(-10)t^2 + (0)t$$

$$-4 = -5t^2$$

$$0.8 = t^2$$

Notice how "−" canceled!

$$\boxed{t = 0.89 \text{ s}}$$

so $t = \sqrt{0.8}$

And for part b)

$$v = at + v_i$$

$$v = (-10)(.89) + 0$$

$$\boxed{v = -8.9 \text{ m/s}}$$

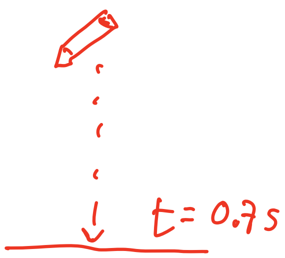
↳ So the speed would be 8.9 m/s

Sample 2

A pencil is dropped and hits the ground after 0.7 seconds.

a) How far did it fall?

b) How fast is it going when it hits the ground?



Given/things you know:

$a = -10\ m/s^2$

$v_i = 0\ m/s$

$t = 0.7\ s$ (to fall)

So for part a)

$$y = \frac{1}{2}at^2 + v_i t$$

$$y = \frac{1}{2}(-10)(.7)^2 + (0)(.7)$$

$$y = -2.45 + 0$$

Don't forget to square the .7!

$$\boxed{y = -2.45\ m}$$

↳ So it fell 2.45 m.

b) $v_f = at + v_i$

$v_f = -10(.7) + 0$

$\boxed{v_f = -7\ m/s}$ → So it is moving 7 m/s when it hits ground.

Sample 3 (Now with an initial velocity)

A ball is thrown up with an initial velocity of 15 m/s. It is caught @ the same height from which it was thrown.

a) How long will it take to reach its maximum height?

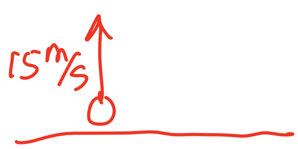
b) what is its maximum height?

c) How long was it in the air?

d) what is its <u>height</u> after only 1 second?

e) what is its <u>velocity</u> after only 1 second?

f) what is its velocity just as it is caught?



Givens & Things You know:

$v_i = 15$ m/s

$a = -10$ m/s^2

$v = 0$ m/s @ maximum height

time to go up = time to come down

So part a) $V_f = at + V_i$

$0 = -10t + 15$

$10t = 15$

$\boxed{t = 1.5 \text{ s}}$

b) $y = \frac{1}{2}at^2 + v_i t$

$y = \frac{1}{2}(-10)(1.5)^2 + (15)(1.5)$

Be careful plugging in #s!

$y = -11.25 + 22.5$

$\boxed{y = 11.25 \text{ m}}$

its + because its higher than it started

c) If it took 1.5 seconds to go up, it will take another 1.5 seconds to fall back down, so the total time in the air is

$1.5 + 1.5 = \boxed{3 \text{ seconds}}$

d) $y = \frac{1}{2}at^2 + v_i t$

$y = \frac{1}{2}(-10)(1)^2 + (15)(1)$

v_i still 15 m/s!

$y = -5 + 15$

$\boxed{y = 10 \text{ m}}$

e) $V_f = at + V_i$

$V_f = (-10)(1) + 15$

$V_f = -10 + 15$

$\boxed{V_f = 5 \ m/s}$

It's positive - so still going up!

f) Since its caught @ same height from which it was thrown, we know the speeds are the same - but opposite velocities

so $V_f = -V_i$

$\boxed{V_f = -15 \ m/s}$

Notice we can calculate this as well:

$V_f = at + V_i$

$V_f = (-10)(3) + 15$

$V_f = -30 + 15$

$\boxed{V_f = -15 \ m/s}$

V_i still 15 m/s but use total time in air