Acceleration 3

Motion at constant acceleration

We discussed earlier that accelerated motion happens whenever velocity changes. If velocity changes at a rate of acceleration(a) that means the velocity ($\vec{V}$) dependence on time (t) looks like this:

$$\vec{V}_{final} = \vec{V}_{initial} + \vec{a}t$$

The average velocity of accelerated movement is the starting velocity plus the final one divided by two. That is how we find the average value:

$$V_{average} = \frac{V_{initial} + V_{final}}{2}$$

We can modify the formula by merging it with the first one:

$$V_{average} = \frac{V_{initial} + V_{final}}{2} = \frac{V_{initial} + V_{initial} + at}{2} = \frac{2 \cdot V_{initial} + at}{2} = V_{initial} + \frac{at}{2}$$

The next thing we would like to know is how far do we travel when accelerating constantly. **Let's try to solve the question**: if we want to explore a vertical cave but do not see the bottom and are not sure that our rope will be long enough. To measure the depth of the cave before going in we can throw a rock there and measure the time it takes to reach the bottom (which we would hear). It would be smart to "throw" the pebble with zero initial velocity, simply let it go from our hand. Then we need to find out how to relate the distance traveled by the pebble to time of travel.

For motion at constant acceleration *a* and starting (initial) speed, the distance after time *t* is:

$$d = V_{initial} \times t + \frac{a \times t^2}{2} = V_{average} \times t$$

Example:

If it took our pebble 3 seconds to fall and we dropped it without any initial speed, $V_{ini} = 0$.
using gravitational acceleration, a=g ~ 10 m/s^2
we calculate the depth of the cave to be:

$$d = \frac{gt^2}{2} = \frac{10 \cdot 3^2}{2}\text{m} = 45 \text{ m}$$

So, a standard 50 m rope will be enough.

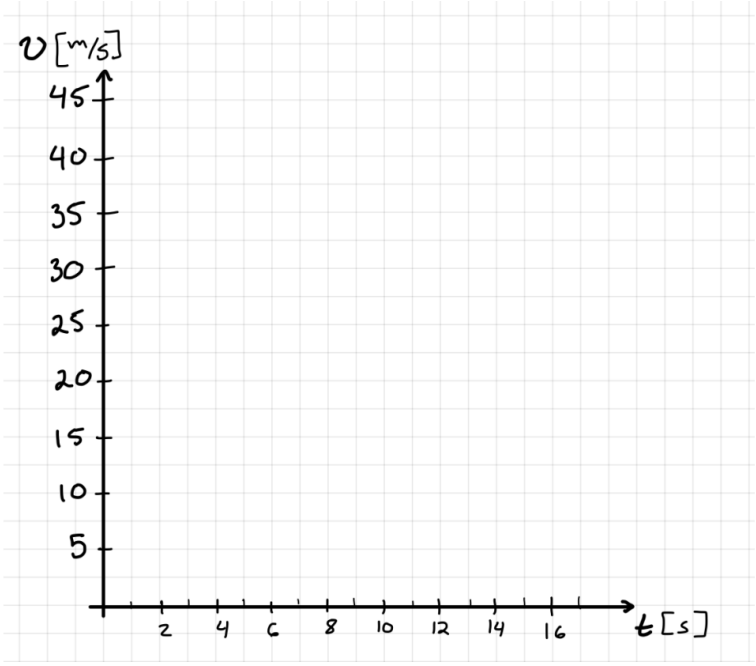
Homework:

1) The car starts at rest at the time t = 0 second. The car accelerates at the rate a = 6 m/s^2 until it reaches a velocity of v = 42 m/s.

(a) How long did it take for the car to reach this velocity?

The car kept this speed for 5 seconds, until the driver saw a police car on the horizon. The driver slammed the brakes bringing the speed of the car down to v = 27 m/s in just 3 seconds.

(b) In the following graph of v vs t, draw the behavior of the velocity of the car.



2) A coin falls for 4 seconds. An initial velocity of the coin was 10 m/s. Find the distance the coin traveled.