1. **Do you know what is common between a sailing ship, a person standing on moving escalator and the Blades of a rotating fan?** (Use stock videos for these examples)

Well, all of them have a constant speed and yet only first two are considered as uniform motion whereas the motion of the blades of a rotating fan are non uniform.

But what is uniform and non-uniform motion?

Wonder or motivational sound till here.

Lets understand this by using Simphy: A physics simulator where anyone can create simulations without any coding.
(Above Text)

2. First we'll create a ground and then place a block on top. Now click on the block and from the properties on the left side, set the velocity as, let's say 4 and attach a ghosting tracer with interval as 1 sec at the centre. Make sure to reduce the simulation speed so that we can observe better.

2. Hit the play button and notice that the blocks are leaving behind a trace of its images at a regular interval of 1 secs. Here these images seem to be equidistant from each other, and obviously this distance is of 4 meters since we gave the velocity of 4m/s
(Animation of arrow btw images with +4 m/s)

Funky/ hip hop sound.

And that is why motions where objects cover equal displacement in equal time interval i.e. their velocity (NOT speed) is constant are called as Uniform motion.

3. This means that even if the speed is constant but its direction is changing then its velocity is changing and such motions are called as non-uniform motion.
(Show simulation of block with 4 m/s changing direction)

No sound.

4.1. For ex. Look at the velocity of the Blades of a moving fan, here the speed is constant but its direction is changing.

4.2. Or look at this ball falling under gravity, here the direction is same but the speed is changing. Notice the images are not equidistant from each other i.e. the ball is covering unequal distance in equal interval of time.

4.3. Or look at this car where both, speed and direction are changing. All these examples are of non-uniform motion.

Soothing sound.

And here things get a little tricky because we are going to calculate the velocity and position at any time during this motion.

But before we get into that, can we calculate the position at any time in case of Uniform motion.

Some sound.

5. Lets go back to our previous simulation, and draw its v-t graph for more clarity, since the velocity is constant throughout the motion, the velocity graph should be a horizontal line, here in 1 sec, our block covered a distance of 4m, in 2 sec, a distance of 8 m i.e. 4x2, in 3 sec, a distance of 12m i.e. 4x3 so in t secs it should cover 4xt m, right? lets verify, I will pause the simulation at any random point and so the distance covered should be 4*t i.e 2.73 sec (t scrolls up with its actual value) i.e. ans… which matches with the actual distance.

Funky/ hip hop sound.

This means that displacement in case of uniform motion is v*t, or area under v-t graph.
(Reveal graph parallel to simulation)

Now calculating velocity is pointless as it is constant however,

No sound.

6. Consider this example, where a block moves with a speed of 2 m/s for 1 sec and then with 3m/s for the next 1 sec, here what is the velocity of the overall motion? Is it 2.. or 3 or somewhere in the middle?

Well, one thing is certain, that this motion is non-uniform as the velocity is changing during the motion.

7. And if we can divide the block's journey into two independent uniform motions then calculating displacement will be easy, and so the displacement will be velocity into time i.e. 2x1 for this journey and 3x1 for this one, covering the total displacement of 5 m in 2 secs.
(Simulation and its graph)

8. So if there's a new block moving with a constant velocity, what velocity should you give such that it covers the same distance as this one in the same time interval. (Happening in the same simulation, animation of empty tracer vector and question mark, distance and time stickers!)

You've 3 secs to guess. (Animation of timer like Dan's video)

Well, the correct ans is 2.5 m/s, because if the block covers 5 m in 2 sec then it must've covered 2.5 m in 1 sec i.e. 2.5 m/s
(Represented graphically, area shifted)

Where this constant velocity can be considered as an average velocity for the overall motion, in fact! average velocity is actually the net displacement over total time taken,
(Represented graphically, area highlighted)

Basically a constant velocity given to another block such that it has the same displacement in the same time interval as the original one.
(During this animation, simulation of both block will be running)

Wonder sound till here.

9. If your guess was not 2.5 m/s then you're not observing carefully. (Say this line doing something crazy like juggling balls without seeing)
Pay attention because the best part of the video is yet to come. (And this one when you fail)

No sound.

10. So tighten your seat belts because now! Our block will move with a velocity of 4 m/s for an additional sec.

10. In this case, the total displacement will be 2 + 3 + 4 i.e. 9 m covered in 3 secs so the average velocity will be… (take a pause) 3 m/s.

11. Now, let the block travel with 5 m/s for another sec, the total displacement will be 2+3+4+5, i.e. 14 m covered in 4 secs, so the average velocity will be 3.5 m/s.

And if you look closely, there's a pattern here, the average velocity is the average of initial and final velocities, even if you reduce this interval (of 1 sec) and also reduce this uniform change in velocity, the result will be the same, no matter how many times you repeat this experiment (Many pillars appearing next to each other in graphs)

As long as the change in velocity and time interval is same for all the velocities.

But here's another thing, reduce the interval and change in velocity to a value very close to zero and the graph becomes a perfect straight line.

So instead of an increment in velocity of 1 m/s after every sec (or "v" m/s after every 't' time for a general case), the velocity now is changing every moment i.e. by dv m/s every dt time (dv and dt are infinitesimally small)

Such motions are called uniformly accelerated motion, where the acceleration is the rate of change of velocity or mathematically written as dv/dt.

So remember when the velocity was constant, displacement was the area under v-t graph, i.e. v*t, here, acceleration is constant, so the change in velocity is the area under a-t graph, i.e. a*t.

This is our first equation of motion.

and since the average velocity would still be the average of initial and final velocity, displacement is average velocity * t or area under v-t graph

This is our 2nd equation of motion.

and the 3rd equation of motion is actually derived from the first two as shown.

Cinematic sound till here.

End with summary in a minute.

So to summarise in short, we first discussed uniform motion where the velocity i.e. both speed and direction are constant and calculated its displacement
(simulation plus graph)

Then we saw an example of non-uniform motion, which is a combination of 2 uniform motions and calculated both displacement & avg velocity.
(simulation plus graph)

After repeating the exp. multiple times, the v-t graph looked something like a staircase. But if we reduced the increment and interval to an infinitesimally small value then it becomes a straight line and the displacement can be calculated using area of v-t graph or using average velocity.

Whereas as change in velocity is a*t.

Soothing sound.

Shorts

1. Do you what is common between a sailing ship, a person standing on moving escalator and the Blades of a rotating fan? … , watch the full video to check the answer in detail

2. Graphs visualisation of average velocity and equation of motion in short, watch the full video for in-depth understanding.

3. Lets see whether you can answer this, there are 2 cars racing each other to the finish line, where first car starts from rest and has an acceleration of 5 m/s^2 and the second car starts with a constant velocity of 10 m/s and moves with the same speed throughout the race, which car do you think will win??