Motion with Constant Velocity

Saba Karakas

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1 Theory

To describe the motion of objects in mathematical language, objects are modeled by point particles. A vector $\vec{r}$, known as the position vector, is introduced to give the position of the moving object with respect to a given origin of coordinates, a reference point. Obviously, this position vector will be a function of time; $\vec{r} = \vec{r}(t)$ since the particle is moving, i.e. changing its position over time. The particle will be at one position $\vec{r}_1 = \vec{r}(t_1)$ at an instant t_1, and at another position $\vec{r}_2 = \vec{r}(t_2)$ at a later instant t_2. The explicit form of the dependence of $\vec{r}$ on t is determined by the specific type of motion of the particle. The **average velocity** of a particle in a given time interval is $\vec{v}_{av}$ and defined as,

$$\vec{v}_{av} = \frac{\vec{r}_2 - \vec{r}_1}{t_2 - t_1} = \frac{\Delta\vec{r}}{\Delta t}, \tag{1}$$

where Δ is the finite difference.
The **instantaneous velocity** on the other hand, which is the rate of change of the position vector at each instant of time, is defined as,

$$\vec{v}_{ins} = \lim_{\Delta t\to 0}\frac{\Delta\vec{r}}{\Delta t} \equiv \frac{d\vec{r}}{dt} \tag{2}$$

1.1 Newton's 1st Law of Motion

Newton's first law of motion states that "a particle at rest stays at rest and a particle in motion stays in motion until an unbalanced external force acts upon it". This statement means that, if the net force acts on a particle is zero, then its velocity does not change. If its velocity is zero, then it doe not move and if its velocity is different from zero, then it stays in its constant motion.

$$\vec{F}_{net} = \vec{0} \quad \Rightarrow \quad \vec{v} = const. \tag{3}$$

Since the velocity does not change in this kind of motion, the motion is in 1 direction. Therefore we may choose one dimension to represent the direction of the motion.

$$\vec{r} = x\hat{i} \tag{4}$$

Then we may rewrite the average and instantaneous velocity in terms of x as follows,

$$v_{av} = \frac{\Delta x}{\Delta t}, \tag{5}$$

$$v = \frac{dx}{dt}. \tag{6}$$

In Eq. 6, we have omitted the subscript "ins" and simply use "v" for instantaneous velocity. When we integrate Eq. 6 to obtain position we get,

$$x(t) = x_0 + vt. \tag{7}$$

In this equation x_0 is the initial position of the particle. In the experiment we will set this position to 0.

2 Procedure

2.1 Experiment Procedure

1. Turn on the lab table and then the airtable.
2. By using only compressor's pedal, make sure the airtable is working.
3. If the airtable is working; turn it off. If not; contact with your lab instructor.
4. Place the carbon paper into the airtable and experiment sheet onto the carbon paper.
5. Set the frequency of the airtable to 20 Hz and write this value down in the Table in Section 3.
6. Turn on the experiment table and the airtable.
7. Secure one of the pucks with a folded piece of paper underneath of it.
8. Push both of the pedals.
9. Give the free puck a small push. It should make a motion with constant velocity. Be careful about that your hand should touch the puck for a really small amount of time.
10. Turn the airtable and the experiment table off.
11. Move the experiment sheet from the airtable to the experiment table.

2.2 Analysis Procedure

1. Determine the very first dot left by the puck and label it as 0.
2. Label the other dots in an increasing manner shown in Fig. 1.
3. With a ruler, measure the length of interval between 0th and n_th dots on the experiment paper. Write the numerical values down on Table(1) in Section(3).
4. Plot the x-t graph using data on Table(1).
5. Calculate the slope of the graph and write it down on Section(3). This is the instantaneous speed.
6. Using the data on Table(1), fill the cells in Table(2).
7. Write example calculations for Table(2) on Section(3).

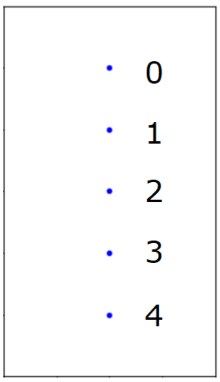

Figure 1: Experiment Sheet.

3 Data & Results

- Frequency of airtable: $f =$ __________________________.

Table 1: __________________________

#	x (cm)	t (sec)
0	0	0
1		
2		
3		
4		
5		

Table 2: __________________________

i	x_i (cm)	t_i (sec)	$i+1$	x_{i+1} (cm)	t_{i+1} (sec)	Δx (cm)	Δt (sec)	V_{av} (cm/sec)
0			1					
1			2					
2			3					
3			4					
4			5					

3.1 Example Calculations

- Calculations for v_{ins}:

- Calculations for Δx:

- Calculations for Δt:

- Calculations for v_{av}:

4 Conclusions

5 Notes