Designed By: Ms. Sonia Nasir
Lecturer NU – FAST

National University
of Computer & Emerging Sciences
(KARACHI CAMPUS)

Chapter: Motion along Straight Line

Topic: Displacement, Velocity & Acceleration Relationship *(Graphical Approach)*

Understand Relation between "d – t" , "v – t"& "a – t" graphs:

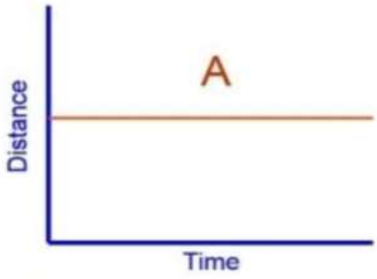
Following are certain scenarios, according to which we will see and verify that when the distance changes velocity changes, as long as velocity changes acceleration will also encounter a change.

We'll take **displacement/velocity/acceleration** along **y–axis** and **time** along **x–axis** respectively.

Scenario # 01

Let us consider a graph between **d and t** is **a straight line** in **positive axes**, as shown in figure **A**

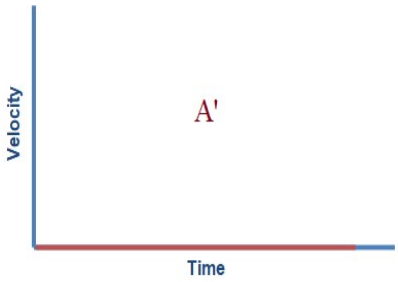
This graph shows that as time goes displacement remains constant, which means the object or vehicle is in rest or stopped.



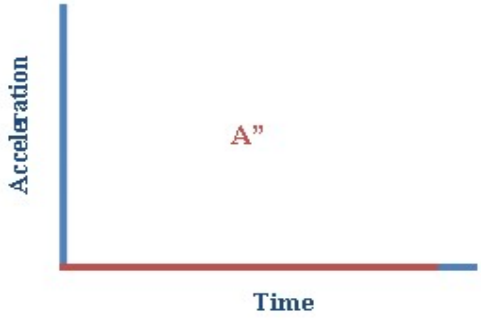
At the same time we can see what will happen with the velocity by drawing a graph.

As the displacement remains constant with the passage of time which shows vehicle is stopped, therefore **velocity will be zero** or there may be no change in velocity.

The red line overlapping x-axis in figure A' showing that velocity is zero but time is increasing.



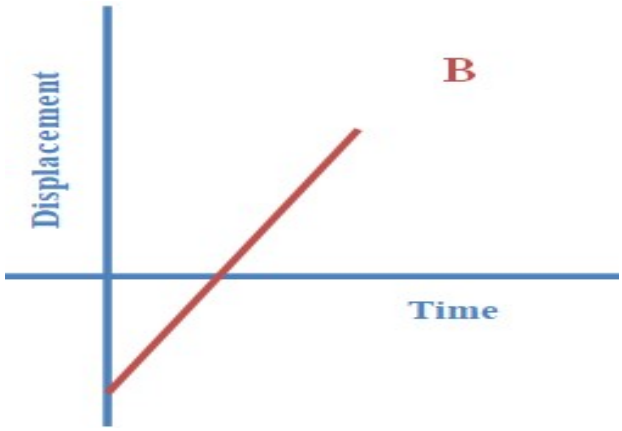
Similarly as the velocity is zero then there will be no change in acceleration so its graph will also be same as velocity time graph.



Scenario # 02

Let us consider the displacement is a kind of increasing just shown in figure B.

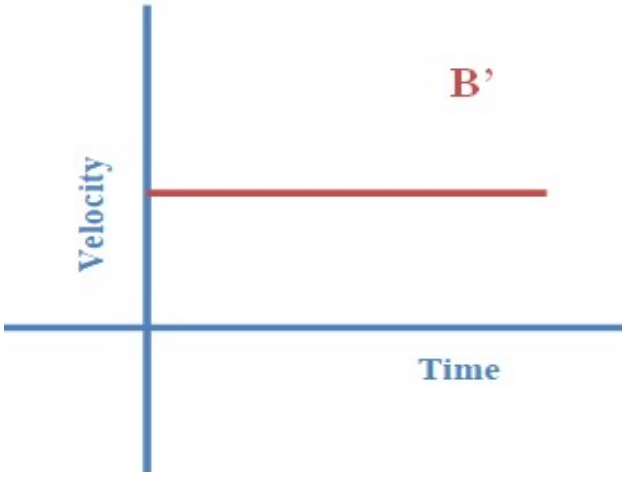
It is increasing in such a way that the **slope at each point is constant** (Slope is the rate of change) also the **slope is positive** and we also know that **rate of change of displacement is Velocity.**



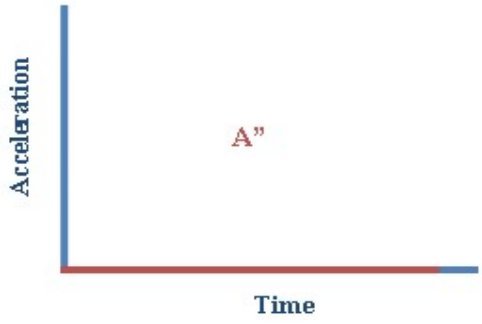
When slope of "**d-t" is constant and positive** that means in terms of **velocity the body is moving with uniform positive velocity**.

In that case the graph of velocity should be drawn as shown in figure B'

It is a **horizontal straight line but constant** in **positive axis**

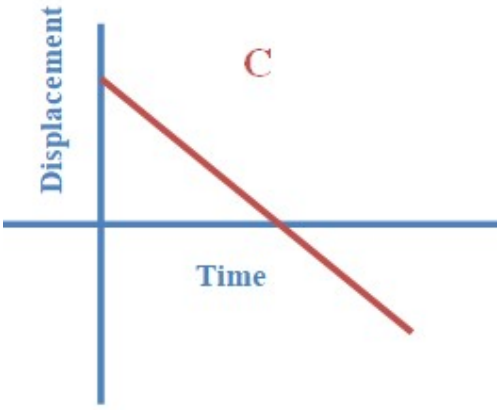


For acceleration , if **velocity is constant** throughout the movement therefore **acceleration will be zero** and the graph will be same as shown in figure A"



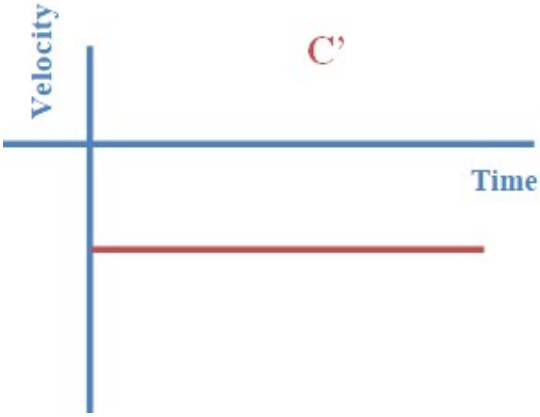
Scenario # 03

Let us consider the displacement is decreasing with the increase in time, such that it comes downward at the reference axis as shown in figure C .

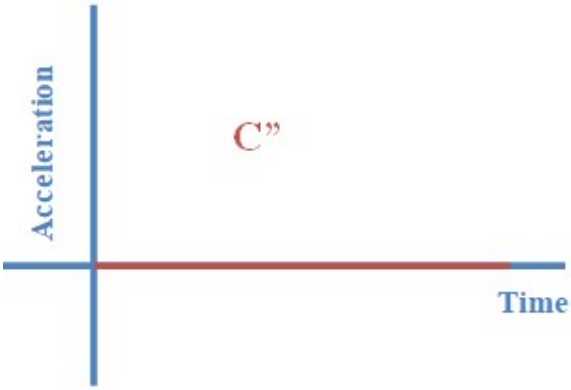


We see that slope is constant at each point but negative which means we are talking about uniform negative velocity.

The graph of this particular scenario is same as graph B' but that horizontal line will be drawn in negative axis or below reference axis (because the slope is negative). As shown in figure C'



For acceleration , if **velocity is constant** throughout the movement therefore **acceleration will be zero** and the graph will be a straight line on reference line as shown in figure C".



Scenario # 04

Now the other scenario is, if the graph is a **parabola** as shown in figure D.

In this graph you will notice that the direction of motion is changing at every instant. This can be conceptualized by drawing tangent on the curved path (tangents shown by green lines).

Observing from left to right, **the direction of tangents** changes from **negative to zero and then zero to positive.**

We make certain sections on this graph to watch what exactly happens at each instant (where the change occurs) therefore just reminding the previous scenarios we will apply those at each section (dotted lines)

For the change in Velocity:

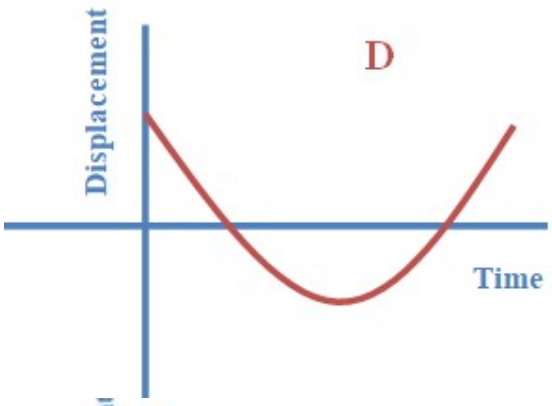
If we draw it on v-t graph as shown in figure D'.

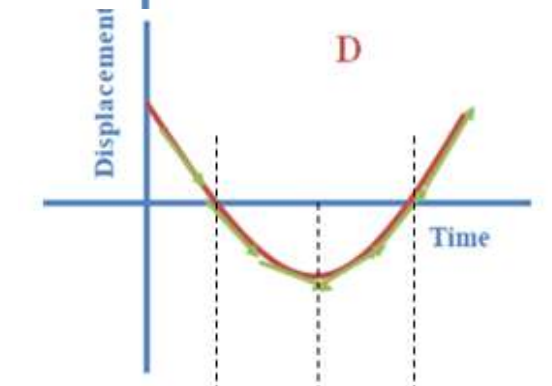
We conclude that :

- At the maximum negative peak (turning point) Velocity is zero at turning point.
- Velocity is negative on left side of turning point.
- Velocity is positive on the right side of after turning point

The acceleration will be constant.

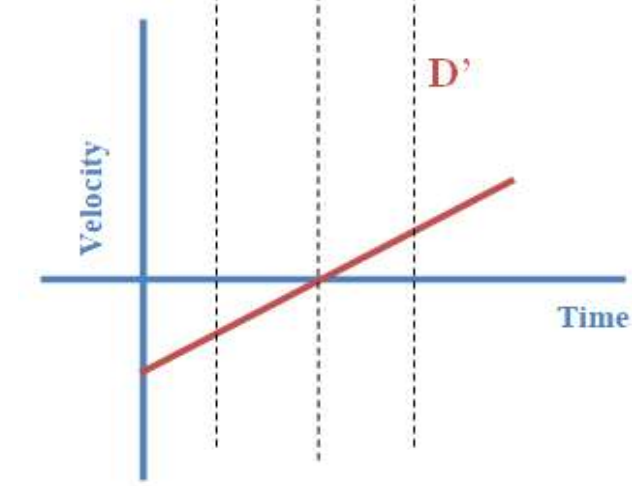
In this case slope is increasing uniformly therefore the **acceleration will remain constant** for this scenario as shown in figure D"

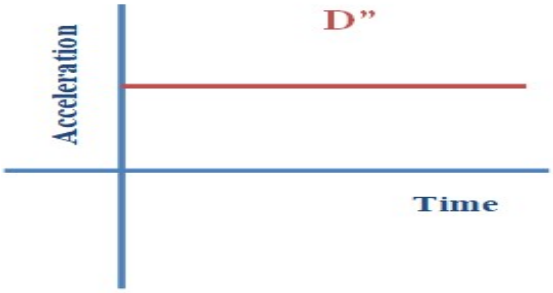




Direction of tangents is from negative to zero to positive

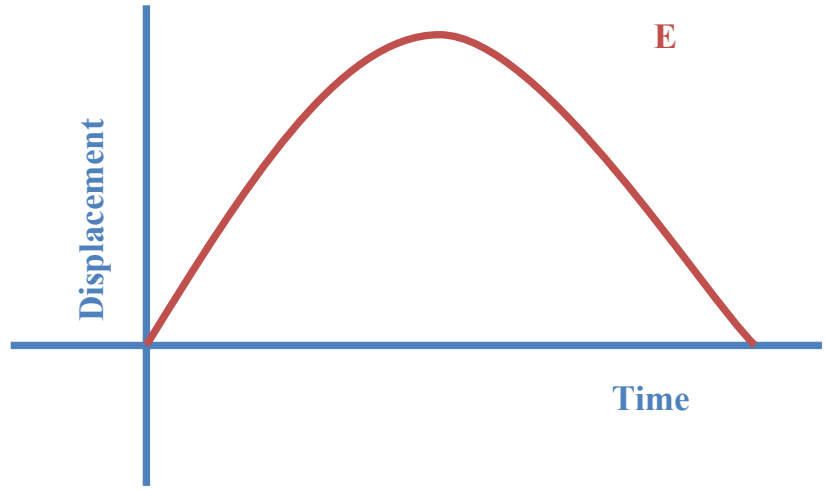
(-ve ⟶ 0(zero) ⟶ +ve)

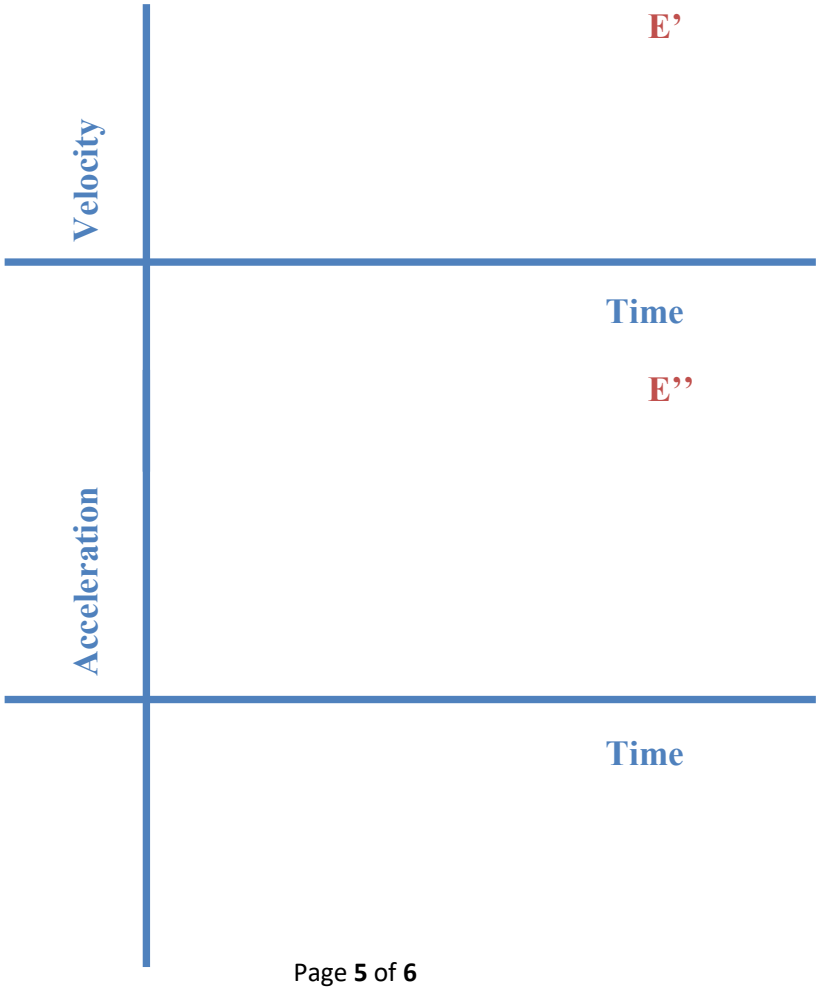




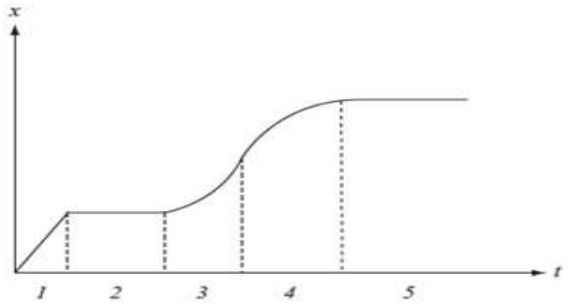
Worksheet # 01

(a) A body is moving along a parabolic path as shown in figure E. It is on the position time graph. Generate some graphical results for velocity and acceleration for that instant. Explain your answer.





(b) Following is the position time graph of a moving bus. Explain status of bus (moving or at rest or uniformly accelerated etc.) at each labeled instants and draw the relevant graph for its velocity and acceleration



Solution:

Key to solve d-t, v-t, a-t Graphs:

- For curve, the graph will change to diagonal line.
- If the graph is diagonal then it will be converted into horizontal li
- And for the horizontal line graph it remains the same but at zero level (Reference line).