ST. LAWRENCE HIGH SCHOOL

A JESUIT CHRISTIAN MINORITY INSTITUTION

- **Subject- Physics Study Material -3 Class IX**
- **Date : 6.05.2020**
- **Chapter: Motion**
- Graph of Displacement vs. Time (*a* = 0, so *v* is constant)

Time is usually an independent variable that other quantities, such as displacement, depend upon. A graph of displacement versus time would, thus, have *x* on the vertical axis and *t* on the horizontal axis. Figure 2 is just such a straight-line graph. It shows a graph of displacement versus time for a jet-powered car on a very flat dry lake bed in Nevada.

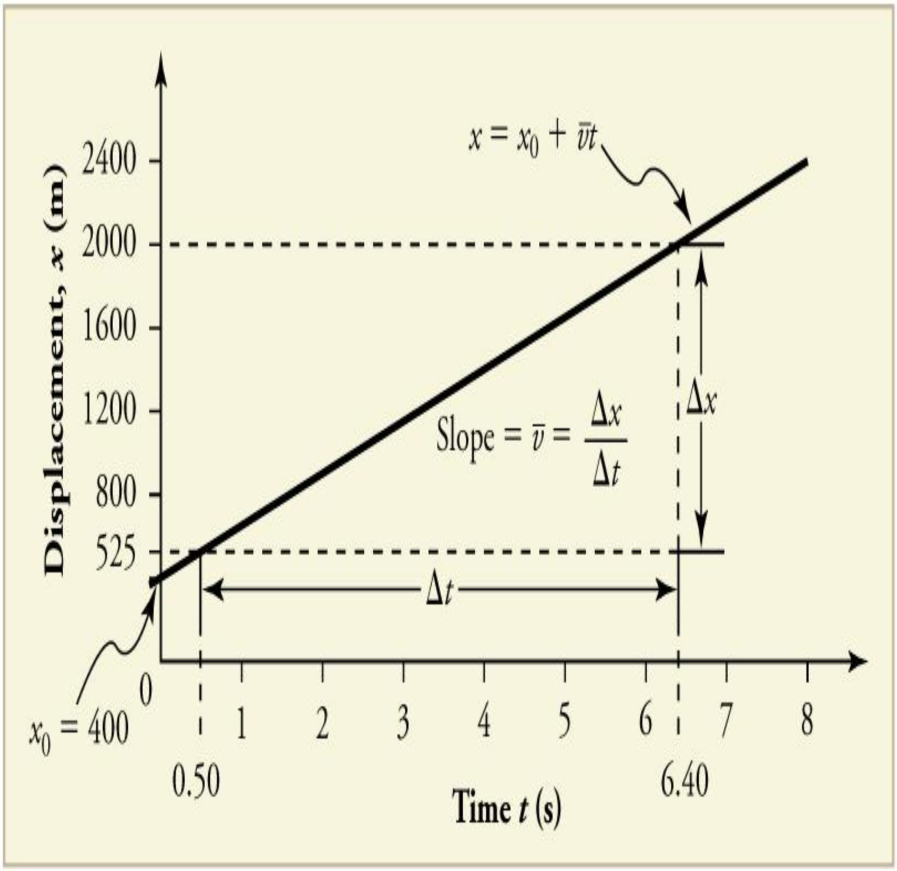

Figure 2. Graph of displacement versus time for a jet-powered car on the Bonneville Salt Flats.

Using the relationship between dependent and independent variables, we see that the slope in the graph above is average velocity ¯vv¯ and the intercept is displacement at time zero—that is, x_0. Substituting these symbols into $y=mx+b$ gives

$$x=\bar{v}t+x_0$$

or

$$x=x_0+\bar{v}t.$$

Thus a graph of displacement versus time gives a general relationship among displacement, velocity, and time, as well as giving detailed numerical information about a specific situation.

THE SLOPE OF *X* VS. *T*

The slope of the graph of displacement *x* vs. time *t* is velocity *v*.

$$\text{slope}=\frac{\Delta x}{\Delta t}=v$$

Notice that this equation is the same as that derived algebraically from other motion equations in **Motion Equations for Constant Acceleration in One Dimension**.

From the figure we can see that the car has a displacement of 400 m at time 0.650 m at t = 1.0 s, and so on. Its displacement at times other than those listed in the table can be read from the graph; furthermore, information about its velocity and acceleration can also be obtained from the graph.

EXAMPLE 1. DETERMINING AVERAGE VELOCITY FROM A GRAPH OF DISPLACEMENT VERSUS TIME: JET CAR

Find the average velocity of the car whose position is graphed in Figure 2.

Strategy

The slope of a graph of *x* vs. *t* is average velocity, since slope equals rise over run. In this case, rise = change in displacement and run = change in time, so that

$$\text{slope}=\frac{\Delta x}{\Delta t}=\bar{v}.$$

Since the slope is constant here, any two points on the graph can be used to find the slope. (Generally speaking, it is most accurate to use two widely separated points on the straight line. This is because any error in reading data from the graph is proportionally smaller if the interval is larger.)

Solution
1. Choose two points on the line. In this case, we choose the points labeled on the graph: (6.4 s, 2000 m) and (0.50 s, 525 m). (Note, however, that you could choose any two points.)

2. Substitute the *x* and *t* values of the chosen points into the equation. Remember in calculating change (Δ) we always use final value minus initial value.

$$\bar{v}=\frac{\Delta x}{\Delta t}=\frac{2000\text{ m}-525\text{ m}}{6.4\text{ s}-0.50\text{ s}},$$

yielding

$$\bar{v}=\text{250 m/s}.$$

Discussion
This is an impressively large land speed (900 km/h, or about 560 mi/h): much greater than the typical highway speed limit of 60 mi/h (27 m/s or 96 km/h), but considerably shy of the record of 343 m/s (1234 km/h or 766 mi/h) set in 1997