LINEAR MOTION

Brief history of the knowledge of motion

Aristotle (384-322 BC) - classified motion into two types, natural and violent. Aristotle taught that all motion resulted from the nature of the object or a sustained push or pull. If an object was in its 'proper' place, it should not move unless it is subjected to a force. The normal state of earthbound objects is one of rest, so if you throw a rock up it must return to the earth.

Copernicus (1473 - 1543) - Published theory of moving earth in his *De Revoltionibus* in 1543.

Galileo Galilei (1564 - 1642) - first to provide alternate description of motion which discredited Aristotle's ideas. Galileo had experimental evidence to support his theories. He used rolling objects on inclined planes to observe the nature of motion. He acknowledged the existence of friction and identified the concept of inertia as a result. Galileo's theory was that if there is no interference with a moving object it will keep moving in a straight line forever, no sustained push or pull required.

FRAME OF REFERENCE

The object or background used to determine motion and its direction. The frame of reference is assumed/defined to be at rest. Everything around us has motion (you, the wall, the air,...). There is no matter that we know of that does not have some type of motion associated with it.

MOTION

Has to start in one position and have at least one change in that position during a period of time. The study of motion requires three basic measurements:

DISTANCE (d) - how far from one position to another As a result of motion an object will travel a certain distance. Distance is measured in units of length - meters (m), feet (ft), miles (mi), etc.

DIRECTION ($\rightarrow$) - How the position changes relative to the starting point: north, south, east, west; positive and negative; up, down, left, right; etc.

TIME (t) - Duration of an event from start to finish. Time as we define it appears to be irreversible and is commonly measured in seconds (s), minutes (min), hours (hr), etc.

HOW FAST?

SPEED (v) - the rate at which distance is covered. Speed is calculated: the distance divided by the time - $v = d/t$ The resulting units are those of distance over time. Instantaneous speed is measured at a specific point (instant). Average speed is the total distance covered divided the total time of the event; this is usually what most people mean when they say “speed”.

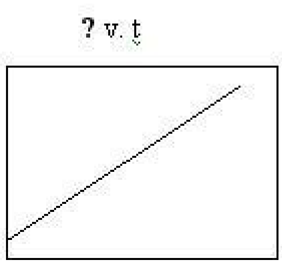
VELOCITY ($\vec{v}$) - The speed and direction of the motion. Velocity involves a change in position known as displacement (Δx). Δ stands for ‘change in’ or ‘final - initial’ and x represents position. For an object to have a velocity the initial and final positions must be different. Velocity is calculated by dividing the displacement by the time interval - $\vec{v} = \Delta x / \Delta t$ Instantaneous velocity is measured at a specific point (instant). Average speed is the total displacement divided the total time of the event.

HOW QUICKLY FAST CHANGES?

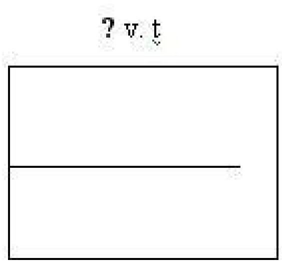
ACCELERATION ($\vec{a}$) - the rate of change in velocity during a time interval. Acceleration is calculated by dividing the change in velocity by the time interval – $\vec{a} = \Delta v/\Delta t$. The units are those of velocity over units of time. The units of acceleration are commonly expressed as units of distance over units of time squared (do the fractions yourself to see why). It is important to remember the time interval, a change in velocity by itself is not sufficient to describe the acceleration of the motion. In everyday language, when there is an increase in speed, we say 'acceleration'; a decrease in speed, we say 'deceleration'. In scientific language both are simply accelerations. An important concept to help understand acceleration is the idea of positive v. negative acceleration. Recall that positive and negative simply represent directions. In displacement and velocity they directly represent the direction of the motion itself. However, since acceleration is a rate of change in the motion itself the direction represented is that of the change in the motion. The following are the four cases of +/- acceleration in linear motion: **(a) a positive acceleration on a positive moving object indicates an increase in speed, (b) a positive acceleration on a negative moving object indicates an decrease in speed, (c) a negative acceleration on a positive moving object indicates an decrease in speed, (d) a negative acceleration on a negative moving object indicates an increase in speed.**

FREEFALL - this is a special case that occurs with objects falling near the surface of the earth. In order to simplify the study of accelerated motion we will often ignore any outside effects, such as friction. When an object falls here on earth there is friction between it and the air which changes as the object accelerates. This variable acceleration is more difficult to deal with mathematically and conceptually and will be reserved for the next unit conceptually. We can, however, closely approximate the "constant" acceleration of an object near the earth's surface if we neglect the air friction. Although this sounds ridiculous, many common objects falling a short distance experience such small amounts of air friction it has little effect on the objects' motion. For example, a golf ball, tennis ball, and a bowling ball will all fall at the same rate (~9.8 m/s^2)from a height of one to two meters. Again, the idea is to start off simple, then add in the complicating issue of friction next unit.

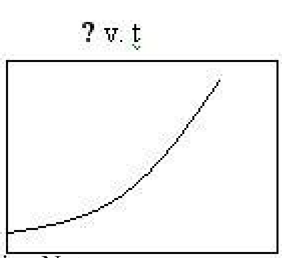
GRAPHICAL REPRESENTATIONS OF MOTION** – **where the "?" can represent distance, position, displacement, speed, velocity. From these graphs you have to be able to describe the motion & slopes



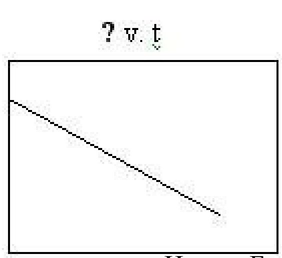
A



B



C



D