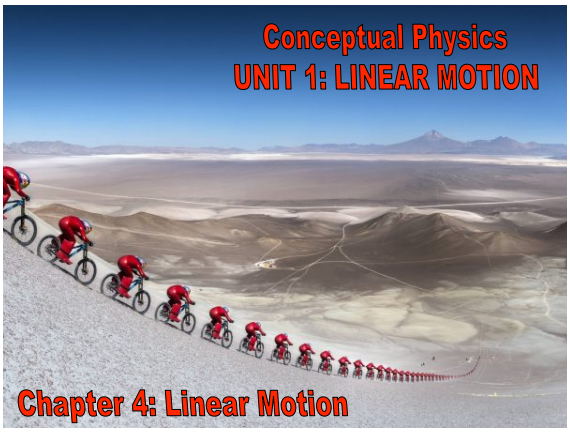


THE BIG IDEA

You can describe the motion of an object by its position, speed, direction, and acceleration.

I. Motion Is Relative (2.1)

A. Everything moves. Even things that appear to be at rest move.

1. Motion is described by motion ***relative*** to something else.

a. Relative to the sun, the center of the galaxy, etc.

b. We will discus motion (things in our environment) relative to the surface of the Earth.

II. ***Speed*** (4.2)

A. ***Speed*** is measure of how fast something is moving (rate at which distance is covered)

1. ***Rate***– term used to describe something divided by time.

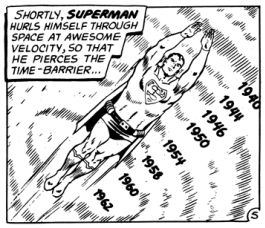
2. ***Speed*** = Units of distance / units of time (distance covered per unit of time)

3. Common Units

a. miles/hour (mi/h)

b. kilometers/hour (km/h)

c. **meters/second (m/s)** Used in physics



•**Continental drift**: 2 mm/year (1mm = one millimeter = 10^{-3} meters)

•**Walking speed**: 3 miles/hour = 4.4 feet/second = 1.3 m/s (1m = 1 meter, s = seconds)

•**Driving speed**: 60 miles/hr = 100 km/hr = 88 ft/s = 26 m/s

•**Orbital speed** (near Earth orbit) = 8 km/s = 17,000 miles/hr

•**Earth's speed around the sun** = 30 km/s

•**Speed of light** = 300,000 km/s = 186,000 miles/s.

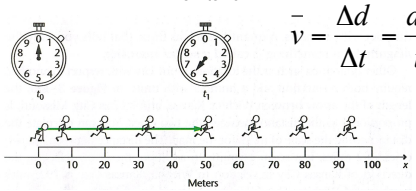
B. ***Instantaneous Speed***– the speed at any instant (What you see on a car's speedometer)

C. ***Average Speed***– total distance covered/time interval

1. Does not indicate variations in speed over time.
2. still describes rate at which distance traveled

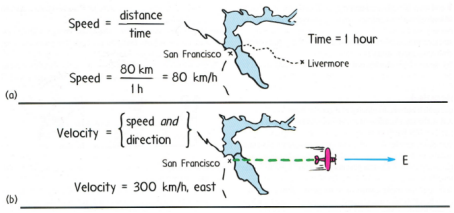
Average speed = $\frac{\text{Total distance covered}}{\text{Time interval}}$

$$\bar{v} = \frac{\Delta d}{\Delta t} = \frac{d_1 - d_0}{t_1 - t_0}$$



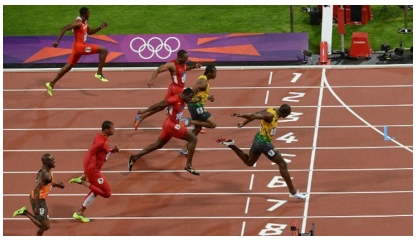
D. ***Velocity*** (4.3)

1. Velocity and speed are often used interchangeably, but in physics are different.
   a. ***Velocity*** is speed in a given direction.
   b. **Speed** is how fast object moves (direction does not matter)



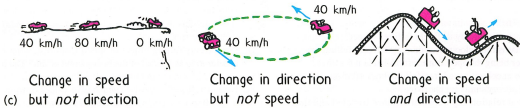
E. ***Constant Velocity***– must have constant **speed** and **direction**

1. Object moves in **straight line**
2. Object's path **does not curve**



F. ***Changing Velocity***

1. Velocity will change if either **speed** or **direction** changes.
2. Constant speed and constant velocity are not the same.



III. ***Acceleration*** (4.4)

A. ***acceleration*** is the rate at which the velocity is changing

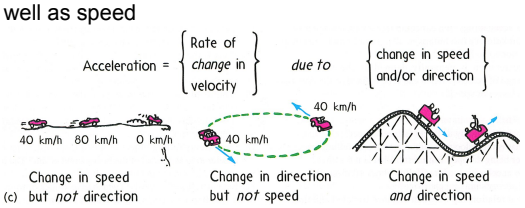
1. applies to increases as well as decreases in
2. decrease in velocity often called ***deceleration*** or ***negative***

acceleration

Acceleration = $\frac{\text{Change of velocity}}{\text{Time interval}}$

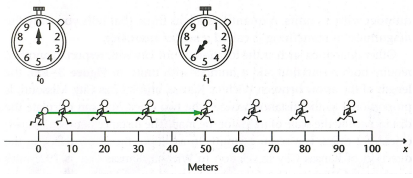
$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{v_1 - v_0}{t_1 - t_0}$$

B. Acceleration applies to changes in direction as well as speed



1. When motion is in straight line the term **speed** and **velocity** are often used interchangeably.

Acceleration along a straight line = $\frac{\text{Change of speed}}{\text{Time interval}}$



2. Units for acceleration a bit more complicated

Acceleration = $\frac{\text{Change of speed}}{\text{Time interval}} = \frac{10 m/s}{1 s} = 10 \frac{m}{s^2}$

IV. Free Fall: How Fast (4.5)

A. The **force of Gravity** causes object to accelerate downward

1. If we disregard air resistance (air friction) then free falling objects only affected
   Called ***free fall***
2. Use letter (***g***) to represent gravity
3. gravity varies slightly around the Earth. Average value is about ***10 m/s²***
4. *More accurately,* ***g = 9.8 m/s²***

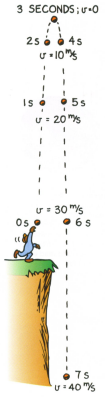
B. The **instantaneous speed** of an object falling from rest is equal to the acceleration multiplied by the amount of time it falls.

Instantaneous speed = acceleration x elapsed time

(**v** symbolizes both speed and velocity)

$$v = gt$$

1. speed decreases at the same rate with an object moving upwards as it increases when moving downward
2. An object thrown upward will reach a velocity of zero when it gets to its highest point



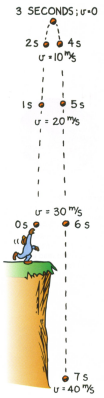
V. Free Fall: How Far (4.6)

A. Relationship between distance traveled, acceleration, and velocity

$$v = gt \qquad d = \frac{1}{2}gt^2$$

Rearrange and solve for t

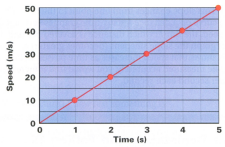
$$t = \sqrt{\frac{2d}{g}}$$



VI. Graphs of Motion

A. Equations and tables not the only way to describe relationships such as velocity and acceleration.

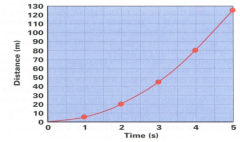
1. ***Linear relationship***– e.g. speed and time



a. Forms straight line curve.
b. Has constant slope (direct proportion)

2. **Parabolic relationship**– e.g. distance versus time

a. Not straight line. Curved line
b. ***Tangent*** at any point gives **slope** at that point (slope of this curve is ***instantaneous speed.*** Remember that ***slope*** is rise/run or change in y over change in x.
Distance/time = speed



VII. Air Resistance and Falling Objects (4.8)

A. ***Air resistance*** noticeably alters the motion of things (like feathers, paper, etc.)

B. Less effect on more dense (compact) objects

C. Air resistance is small enough to be neglected in most ca

VIII. How Fast, How Far, How Quickly. How Fast Changes (4.9)

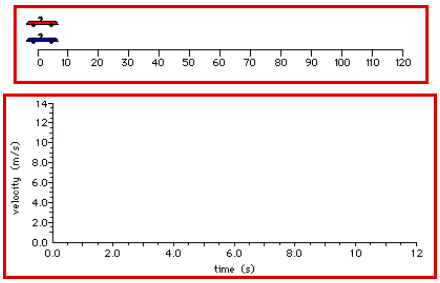
A. speed and velocity-used to describe **how fast** something free falls from rest.

equation to use: $v = gt$

$$v = v_0 + gt$$

B. To specify **how far** the object has fallen we are talking about distance.

equation to use: $d = \frac{1}{2} g t^2$



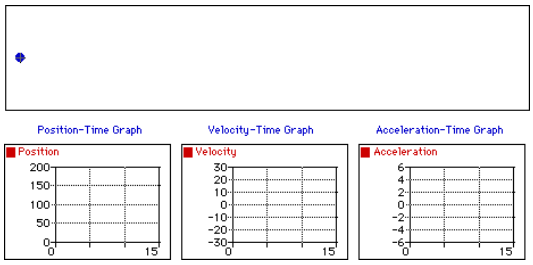
What is this graph telling us?

Change in velocity over time = **acceleration**

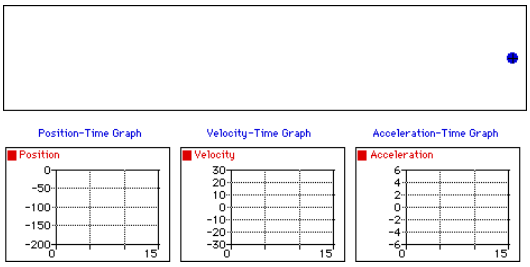
C. Acceleration– how quickly does speed or velocity change

1. Very complex concept
2. rate of a rate

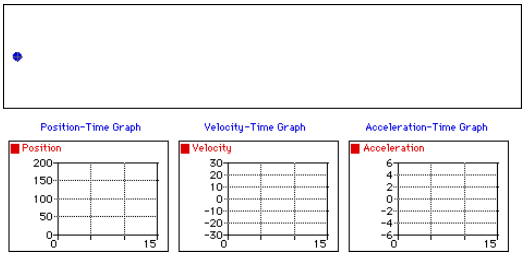
Constant Positive Velocity



Constant Negative Velocity



Positive Velocity and Positive Acceleration



Positive Velocity and Negative Acceleration