Physics

Lesson Plan #3
Describing Motion
David V. Fansler
Beddingfield High School

Picturing Motion
Objective – Draw and use motion diagrams to describe motion; Use a particle model to represent a moving object.

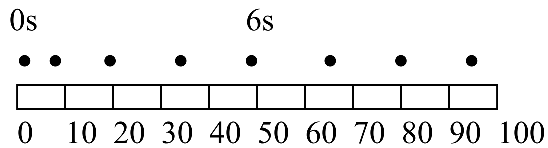
Linear Motion

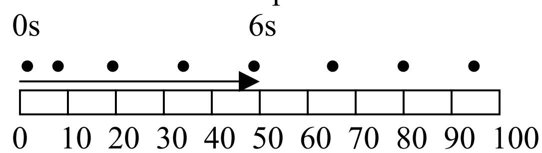
- 4 types of linear motion
  - At rest, speeding up, constant speed, slowing down
  - Draw stick diagram of runner doing each
- Particle Model – instead of the entire moving object considered, just a point at the center of mass
  - Draw the above diagrams again using a particle model

Where and When?
Objective – Choosing Coordinates, Differentiate between Scalar & Vector; Displacement Vector; Signs of vector quantities

- Coordinate System
  - Arbitrarily chosen to fit your needs
    - Show origin on left and right of runner start
  - Origin – where variables are 0
  - One dimension motion requires one axis (x)
  - Two dimension motion requires two axis (x,y)
  - Distance between origin and a point is a **position vector**
  - You can have negative vectors (time, distance) – position prior the start of a race or origin
- Vectors & Scalars
  - Scalar – quantity that expresses magnitude only (time, mass, temperature)
  - Represented by a simple letter (t, m, T)
  - Vector – magnitude and direction
    - Draw a map of Wilson, Raleigh, Durham, Oriental
    - Draw an line with arrow to show distance and direction
    - Represented by a letter with an arrow above it, $\vec{v}$ for velocity or $\vec{a}$ for acceleration, or bold face letters

- Displacement Vector and Time Intervals
  - Motion depends on scalar quantity time and the vector quantity displacement

- Displacement defines the distance and direction between two points
- For a runner, you have the start line and the finish line (d_0 & d_1), so $\Delta d = d_1 - d_0$
- In addition you have time interval t_0 (start) and t_1 (end) so $\Delta t = t_1 - t_0$
- 

- In the above diagram for the runner for the 1st 50 meters
    - $\Delta d = d_1 - d_0$ where $d_0 =$ and $d_1 = 50m$ therefore $\Delta d = 50m$
    - $\Delta t = t_1 - t_0$ where $t_0 = 0s$ and $t_1 = 6s$ therefore $\Delta t = 6s$
    - Now we can draw the displacement vector
    - 

      The length of the displacement vector is the distance, which is a scalar quantity
      Tail of arrow is at the earlier position and head at the later position

- Velocity and Acceleration

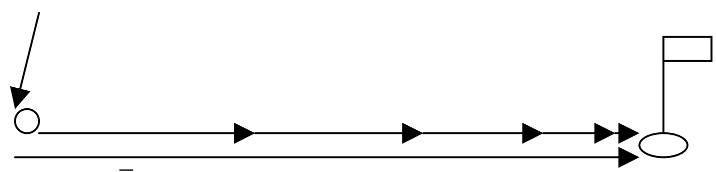
Objectives – Define velocity and acceleration operationally, Relate the direction and magnitude of velocity and acceleration vectors to the motion of objects, Create pictorial and physical models for solving motion problems.

- Velocity
    - How do you measure your speed while driving? (miles/hour)
    - In unit terms that is distance/time or $\Delta d/\Delta t$
    - Example of a person running long distance measured over 100m
    - This is a vector in the same direction as the displacement
    - Average velocity is $\bar{v} \equiv \left(\frac{\Delta d}{\Delta t}\right) = \left(\frac{d_1 - d_0}{t_1 - t_0}\right)$ where $\equiv$ means the left hand side of the equation is defined by the right hand side – note that $\bar{v}$ is over a specific for a specific time interval over the distance covered in that time interval.
    - Average speed is $\Delta d/\Delta t$, but for the total distance traveled.
        - If you took a trip from here to the RBC Center to watch the Hurricanes play, your avg speed would be the distance from Wilson to the RBC Center/how long it took you to get there say 88km/60 minutes = 88km/hr
        - If you only measured the interval from I-95 until you entered Knightdale then you would have traveled 40km in

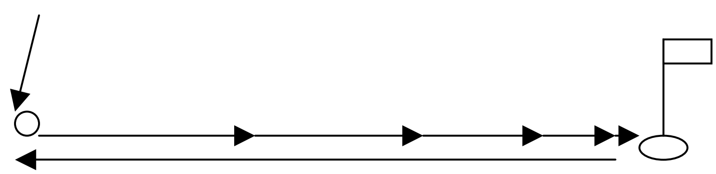
21 minutes, so your avg vel would be 40km/21min = 1.9 km/min = 114 km/hr

- Instantaneous velocity
  - In the trip from I-95 to Knightdale our speed would have change some, as well as our direction – we may have made a wrong turn and gone the wrong direction before turning around – so average speed or velocity is just that, an average with no regard to what happened in the time interval
  - If you were to measure the speed and direction of an object at a particular instant in time, you would have the instantaneous velocity – noted as simply velocity with a symbol of v

- Average Velocity Motion Diagrams
  - Average velocity ($\bar{v}$) vector has the same direction as the displacement vector, not the same units (m vs. m/s)
  - Using $\bar{v} = \left(\frac{\Delta d}{\Delta t}\right)$, then $\Delta d = \bar{v}\Delta t$
  - Since $\Delta d = d_1 - d_0$ then $d1 - d_0 = \bar{v}\Delta t$ or $d_1 = d_0 + \bar{v}\Delta t$ which shows that over the interval of time Δt, the average velocity of an object results in a change of position equal to $\bar{v}\Delta t$
  - No avg velocity – no change of position
  - Example – golf putt



Origin $\bar{v}$ is positive +x



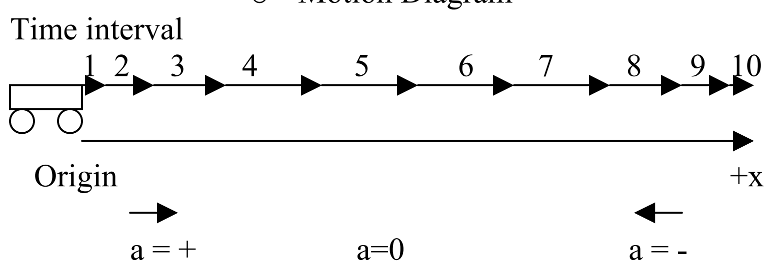
+x $\bar{v}$ is negative Origin

Sign of average velocity depends on the chosen coordinate system

- Acceleration
  - In the above figure, the shorten average velocity vectors indicate that the average velocity was changing from one time interval to

the next – this would indicate that the instantaneous velocity is changing also

- An object whose velocity is changing is said to be accelerating
- Stated in terms of change of velocity per time unit
- Average acceleration is $\overline{a} \equiv \frac{\Delta v}{\Delta t} = \frac{v_{1-} v_0}{t_1 - t_0}$
- Units – velocity is m/s, acceleration is m/s/s = $\frac{m}{s^2}$
- Motion Diagram



Average velocity is increasing in time intervals 1, 2, 3 therefore acceleration is positive

Average velocity is constant in time intervals 4,5,6,7, therefore acceleration is 0

Average velocity is decreasing in time intervals 8,9,10, therefore acceleration is negative