

September 10, 2010 Physics 121 Prof. E. F. Redish

■ **Theme Music:**
Speed Racer Theme

■ **Cartoon:** Charles Schultz / Jef Mallett
Peanuts / *Frazz*

9/10/10

Coordinates and Vectors

- Set up a coordinate system
 - Pick an origin
 - Pick perpendicular directions
 - Choose a measurement scale
- Each point in space is then specified by three numbers: the x, y, and z coordinates.
- The position vector for a particular position is an arrow drawn from the origin to that position.

9/10/10 Physics 121 3

Graphing Position

- Graphs for the eye vs. graphs for the mind.
- Describe where something is in terms of its coordinate at a given time.
 - Choose origin
 - Choose axes
 - Choose scale
 - Set scales on graph
 - Take data from video

9/10/10 Physics 121 4

Writing the math

- Position at a clock time t : $\vec{r}(t) = x(t)\hat{i} + y(t)\hat{j}$
- Position at a clock time t :
(in 1-D, if we don't want to emphasize direction) $x(t)$
- Change in position between two times (t_1 and t_2) $\Delta\vec{r} = \vec{r}(t_2) - \vec{r}(t_1)$
- Time interval $\Delta t = t_2 - t_1$

9/10/10

Physics 121

8

Displacement

- The displacement is the total change in position.
- If you make one change and then go back, it could cancel out the first change.

$$\begin{aligned}
 \vec{r}(t_1) &\rightarrow \vec{r}(t_2) \rightarrow \vec{r}(t_3) \\
 \Delta\vec{r}_{12} &= \vec{r}(t_2) - \vec{r}(t_1) \\
 \Delta\vec{r}_{23} &= \vec{r}(t_3) - \vec{r}(t_2) \\
 \Delta\vec{r}_{13} &= \Delta\vec{r}_{12} + \Delta\vec{r}_{23} \\
 &= \vec{r}(t_2) - \vec{r}(t_1) + \vec{r}(t_3) - \vec{r}(t_2) \\
 &= \vec{r}(t_3) - \vec{r}(t_1)
 \end{aligned}$$

9/10/10

Physics 121

9

Average Velocity

- We need to keep track not only of the fact that something has moved but how long it took to get there.
- Define the average velocity by

$$\langle \vec{v} \rangle = \frac{\text{displacement}}{\text{time it took to make the displacement}}$$

$$\langle \vec{v} \rangle = \frac{\Delta\vec{r}}{\Delta t}$$

9/10/10

Physics 121

10

Uniform motion

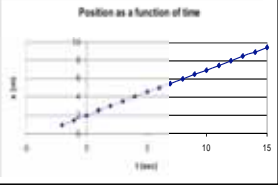
- If an object moves so that it changes its position by the same amount in each unit of time, we say it is in uniform motion.
- This means the average velocity will be the same no matter what interval of time we choose.

$$\langle \vec{v} \rangle = \frac{\Delta \vec{r}}{\Delta t} = v_0$$

$$\Delta \vec{r} = v_0 \Delta t$$

$$\vec{r}(t_2) - \vec{r}(t_1) = v_0 \Delta t$$

$$\vec{r}_{final} = \vec{r}_{initial} + v_0 \Delta t$$



9/10/10
Physics 121
11

Making Sense of the Equation

- Consider a familiar example.
 - If you were to drive North on US 95 for 2 hours (on a Sunday morning when there wasn't much traffic) and could average 60 mi/hr, how far would you have gone?
 - Suppose there was traffic and you could only average 30 mi/hr. How long would it take you to go the same distance?
- Now do it with the equation.
 - 23 mi/hr?

9/10/10
Physics 121
16

Instantaneous velocity

- Sometimes (often) an object will move so that it is not in uniform motion. Sometimes it moves faster, sometimes slower, sometimes not at all.
- We want to be able to describe this change in motion also.
- If we consider small enough time intervals, the motion will look uniform — for a little while at least.

9/10/10
Physics 121
17

Instantaneous velocity

- If we consider a small enough time interval so that the object is (approximately) in uniform motion during that time interval, we can define the “velocity at the instant at the center of the time interval” by

$$\vec{v}(t) = \frac{d\vec{r}}{dt}$$

$$\vec{v}(t) = \frac{\vec{r}(t + \Delta t/2) - \vec{r}(t - \Delta t/2)}{\Delta t}$$

9/10/10

Physics 121

18

Instantaneous velocity

- The instantaneous velocity is like attaching the reading on your car's speedometer to an arrow pointed in the direction you are going.
- Both the size and direction can change from instant to instant.

9/10/10

Physics 121

19

How the Sonic Ranger works

- The sonic ranger has a speaker and a microphone.
- The speaker makes clicks (about 30 per second)
- The microphone detects the echo from the nearest object in front of it.
- The computer measures the time delay between sending the click and receiving the echo.
- The computer calculates the distance using the speed of sound.



9/10/10

Physics 121

20

