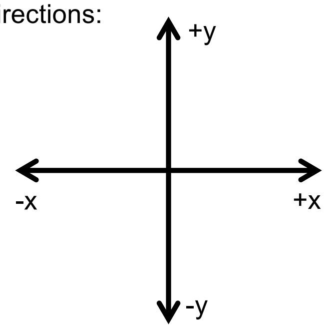
Flipping Physics Lecture Notes:
Introduction to Displacement and the Difference between Displacement and Distance

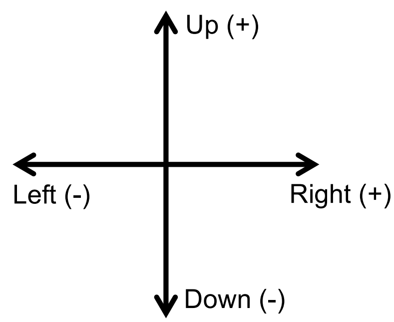
Displacement:

- The straight-line distance between the initial and final points
- The symbol is Δx, where Δ means “change in” and x means “position”
- The change in position of an object
- $\Delta x = x_f - x_i$ (read, displacement equals position final minus position initial)
- Can be either positive or negative
- Possible dimensions: meters, feet, kilometers, furlongs, rods, ångström, etc (any linear dimension)
  - This number is the Magnitude or amount of the displacement
- Has both magnitude and direction
- Displacement ≠ Distance

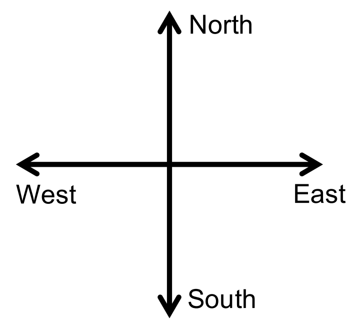
Directions:



Cartesian Coordinates



Relative Directions



Cardinal Directions

The 3 examples are done in the video don’t really need lecture notes.

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Flipping Physics Lecture Notes: Introduction to Velocity and Speed

Velocity: Symbol is lowercase v. Equation is: $\boxed{v=\frac{\Delta x}{\Delta t}=\frac{x_f-x_i}{t_f-t_i}}$

Velocity has both Magnitude and Direction.

Example problem: Mr.p takes his dog Buster for a walk. If they walk for 27 minutes and travel 1.89 km East, what is their average velocity in meters per second?

Knowns: Δt = 27 minutes, Δx = 1.89 km East, v_{avg} = ?

$$v=\frac{\Delta x}{\Delta t}=\frac{1.89km}{27\min}\times\frac{1000m}{1km}\times\frac{1\min}{60\sec}=1.1\overline{6}\approx\boxed{1.2\frac{m}{s}East}$$

Speed: $\boxed{speed=\frac{distance}{time}}$

Speed has Magnitude only with no direction

Velocity ≠ Speed just like Displacement ≠ Distance

Flipping Physics Lecture Notes: Average Velocity Example Problem with Three Velocities

Example Problem: Buster and mr.p embark on a southward journey. First they walk South at 6.5 km/hr for 1.1 hours. Then they stop to take a nap for 18 minutes and then continue South at 5.5 km/hr for 1.2 hours. (a) What was their average velocity for the whole trip? (b) What was their displacement for the whole trip?

Knowns: $v_1 = 6.5\frac{km}{hr};\ \Delta t_1 = 1.1hr;\ \Delta t_2 = 18\min \times \frac{1hr}{60\min} = 0.3hr;\ v_2 = 0;\ v_3 = 5.5\frac{km}{hr};\ \Delta t_3 = 1.2hr$

(a) v_{total} = ? (b) Δx_{total} = ? (all directions are South)

$$v = \frac{\Delta x}{\Delta t} \Rightarrow (\Delta t)v = \frac{\Delta x}{\Delta t}(\Delta t) \Rightarrow v\Delta t = \Delta x \Rightarrow v_1\Delta t_1 = \Delta x_1 \Rightarrow \Delta x_1 = \left(6.5\frac{km}{hr}\right)(1.1hr) = 7.15km$$

$\Delta x_2 = v_2\Delta t_2 = (0)(0.3) = 0km$ & $\Delta x_3 = v_3\Delta t_3 = \left(5.5\frac{km}{hr}\right)(1.2hr) = 6.6km$

Part	Δt (hr)	v $\left(\frac{km}{hr}\right)$ South	Δx (km)
1	1.1	6.5	7.15
2	0.3	0	0
3	1.2	5.5	6.6

$\Delta x_t = \Delta x_1 + \Delta x_2 + \Delta x_3 = (7.15) + 0 + (6.6) = 13.75 \approx \boxed{14km\,South}$ Answer to Part (b)

Part (a) $\Delta t_t = \Delta t_1 + \Delta t_2 + \Delta t_3 = (1.1) + (0.3) + (1.2) = 2.6hr$

$$v_t = \frac{\Delta x_t}{\Delta t_t} = \frac{13.75km}{2.6hr} = 5.28846 \approx \boxed{5.3\frac{km}{hr}South}$$

Note: $\frac{v_1 + v_2 + v_3}{3} = \frac{7.15 + 0 + 6.6}{3} = 4.58\overline{3} \neq 5.28846 = v_{avg}$

This is only true if each part is for an equal amount of time.

Flipping Physics Lecture Notes:
Example Problem: Velocity and Speed are Different

Example Problem: Buster and mr.p embark on a walk. If they leave mr.p's house, travel a distance of 1.2 km and return back to the house 12 minutes & 13 seconds later, (a) what was their average speed and (b) what was their average velocity? Give answers in meters per second.

Knowns: $distance = 1.2km \times \frac{1000m}{1km} = 1200m; \quad time = 12\min \times \frac{60\sec}{1\min} + 13\sec = 733\sec$

(a) $Speed_{avg}$ = ? & (b) v_{avg} = ?

(a) $speed = \frac{distance}{time} = \frac{1200m}{733\sec} = 1.63711\frac{m}{s} \approx \boxed{1.6\frac{m}{s}}$

(b) $v = \frac{\Delta x}{\Delta t} = \frac{0}{\Delta t} = \boxed{0}$

They started and ended in the same location, therefore the straight-line distance between where they started and ended is zero. Hence, displacement equals zero. Therefore velocity is also zero.

Remember Velocity ≠ Speed and Speed is *not* simply velocity without direction.

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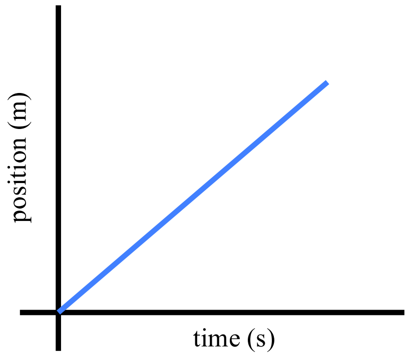
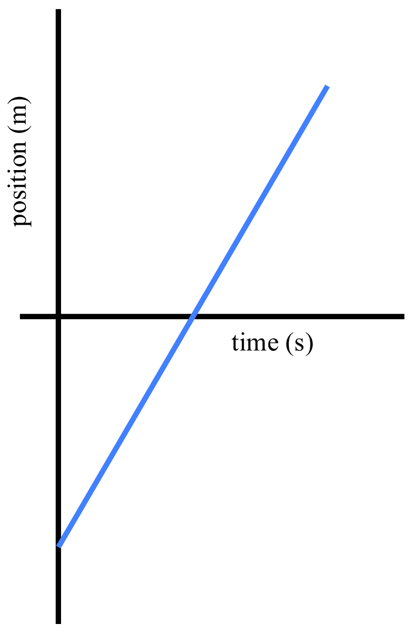
Flipping Physics Lecture Notes:
Understanding, Walking and Graphing Position as a function of Time



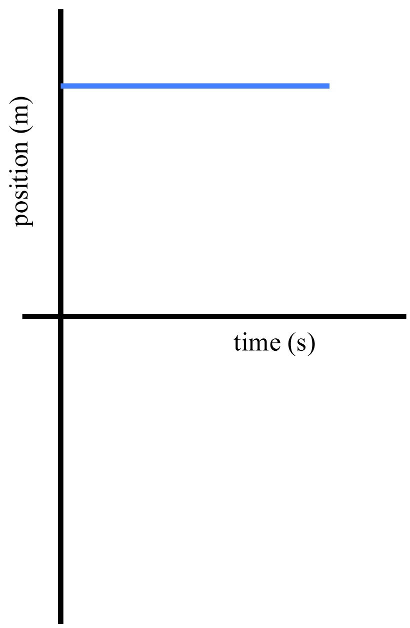
$$slope = m = \frac{rise}{run} = \frac{\Delta y}{\Delta x} = \frac{\Delta position}{\Delta t} = velocity$$

The slope of a position versus time graph is velocity

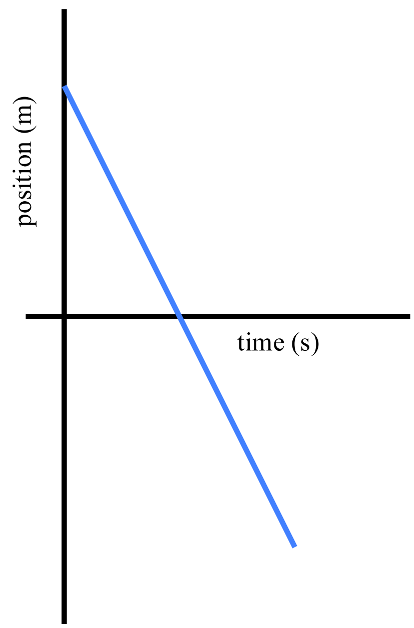
Example #1



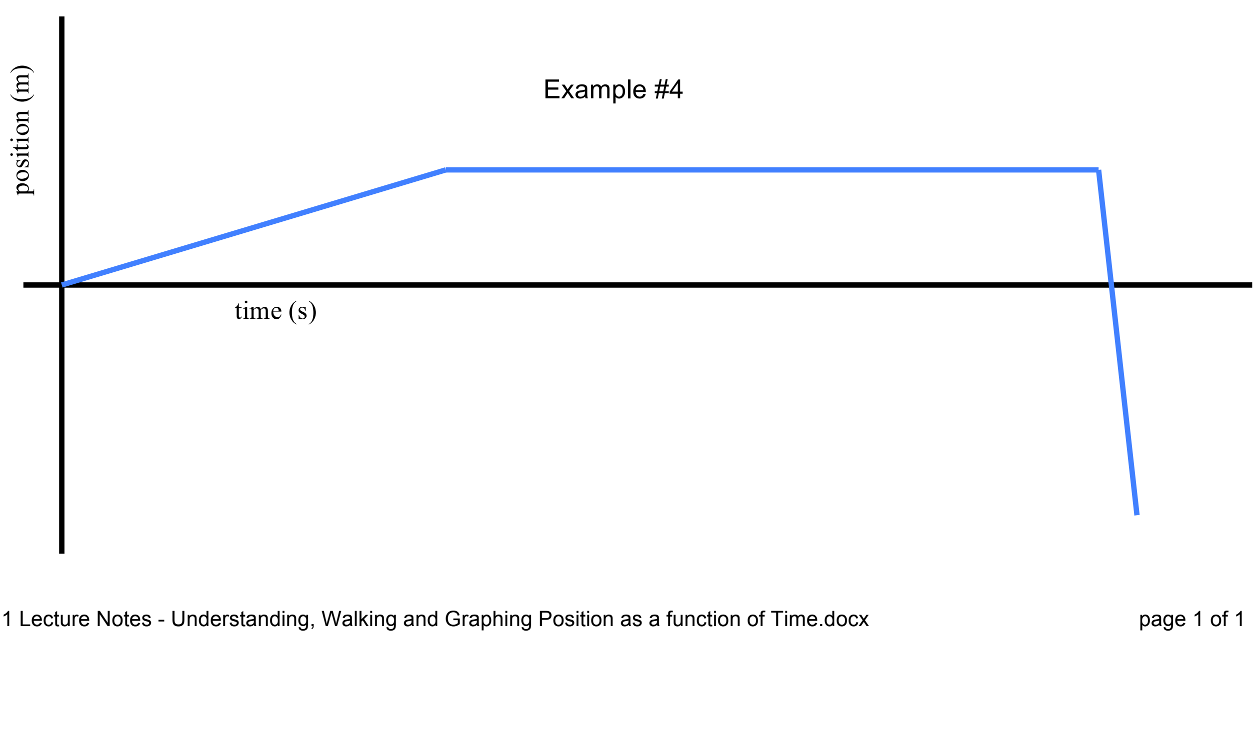
Example #2



Example #3



Example #4



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Flipping Physics Lecture Notes:

Example Problem: Finding Average Speed for Pole Position – Not as easy as you think

Example: During the 2010 Indy 500 Hélio Castroneves won pole position by averaging 228.0 miles per hour (mph) for four 2.500 mile laps. If he averaged 222.0 mph for the first 2 laps, what must his average speed have been for the last two laps? (you may assume the number of laps is exact)

Knowns: d_{lap} = 2.500 miles, s_1 = 222.0 mph, s_2 = ?, d_1 = 2 x 2.5 miles d_1 = 5 miles = d_2, s_t = 228.0 mph & d_t = 4 x 2.5 miles = 10 miles

$$Speed = \frac{distance}{time} \Rightarrow s = \frac{d}{t} \Rightarrow s(t) = \left(\frac{d}{t}\right)t \Rightarrow s(t) = d \Rightarrow \frac{s(t)}{s} = \frac{d}{s} \Rightarrow t = \frac{d}{s}$$

$$\Rightarrow t_1 = \frac{d_1}{s_1} = \frac{5}{222} = 0.0.0225225hr \ \& \ t = \frac{d}{s} \Rightarrow \frac{mi}{mi/hr} = \frac{mi}{1} \times \frac{hr}{mi} = hr$$

(flip the guy and multiply!!)

$$\Rightarrow t_t = \frac{d_t}{s_t} = \frac{10}{228} = 0.0438596hr \ \& \ t_t = t_1 + t_2 \Rightarrow t_2 = t_t - t_1 = 0.0438596 - 0.0225225 = 0.0213371hr$$

$$s_2 = \frac{d_2}{t_2} = \frac{5}{0.0213371} = 234.333 \approx 234.3\frac{mi}{hr}$$

Please notice that students will still want to say that:

$$s_t = \frac{s_1 + s_2}{2} \Rightarrow 228 = \frac{222 + s_2}{2} \Rightarrow 228(2) = 222 + s_2 \Rightarrow s_2 = 228(2) - 222 = 234.0\frac{mi}{hr}$$

Which is clearly not true because 234.0 ≠ 234.3 & that $s_t = \frac{s_1 + s_2}{2}$ is only true if the two speeds are for the same *time* not the same distance.

Please note that Castroneves' recorded average speed actually had 6 significant figures and was 227.970, however, we only used 4 significant figures so that it would be easier to show how people incorrectly predict the necessary speed. Also, there is no way that he could average 234 miles per hour for 2 laps, sorry.