Position, Displacement, Distance

Motion: Where? How much?

Kinematics Unit Outline

I. Vectors

II. Six Definitions:
Distance, Position, Displacement,
Speed, Velocity, Acceleration

III. Two Equations:
Velocity, Displacement

IV. Freefall

	The student will be able to:	HW:
1	Define and distinguish the concepts scalar and vector. Make the connection between the visual representation of a vector and its numerical representation of magnitude and direction angle.	✓
2	Define, distinguish, and apply the concepts: distance, displacement, position.	1, 2
3	Define, distinguish, and apply the concepts: average speed, instantaneous speed, constant speed, average velocity, instantaneous velocity, constant velocity.	3 – 7
4	Define, distinguish, and apply the concepts: average acceleration and instantaneous acceleration, and constant acceleration.	8 – 16
5	State the displacement and velocity relations for cases of constant acceleration and use these to solve problems given appropriate initial conditions and values.	17 – 28
6	State and apply to applicable scenarios the conditions of freefall, including the value of g, and solve related problems.	29 – 41

Where is the Pinnacle? How far?

Definitions:

- **Position** is a vector indicating the location of an object; linear distance and direction from a point of reference. Symbols: $\vec{r}$, $\vec{s}$, or $\vec{x}$

- **Displacement** is the net change in position. Symbols: $\vec{d}$ or $\Delta\vec{r}$ or $\Delta\vec{x}$

- **Distance** is length of the path traveled. Symbol: d or s or x

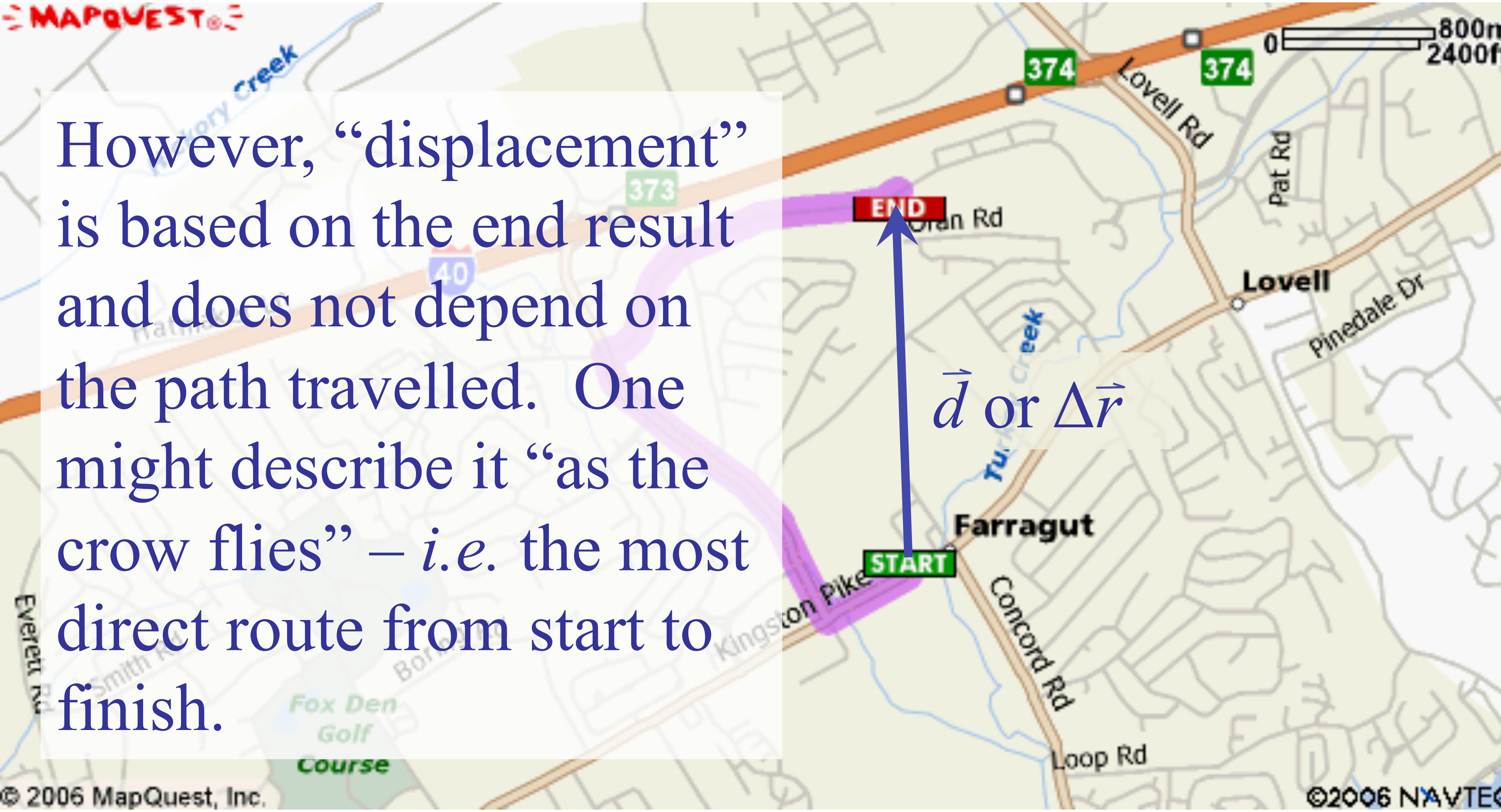
Example: You drive from FHS to the Pinnacle Theatre – how do the concepts apply to this motion?

If you drive from FHS to the Pinnacle then "distance" is the length of the road(s) you take:

distance = 4120 m

FHS to the Pinnacle

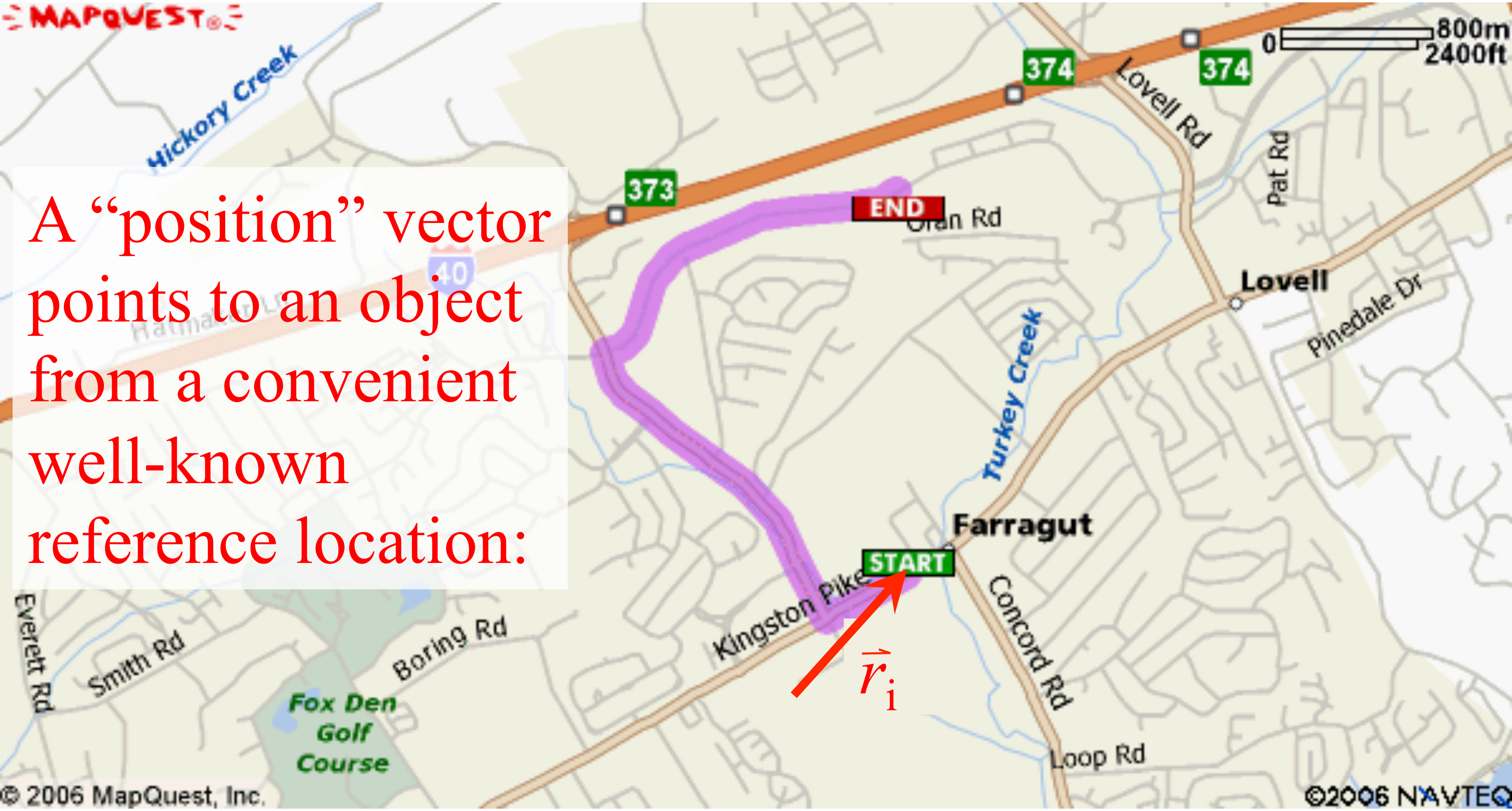
However, "displacement" is based on the end result and does not depend on the path travelled. One might describe it "as the crow flies" – *i.e.* the most direct route from start to finish.



displacement = 1850 m, 92°

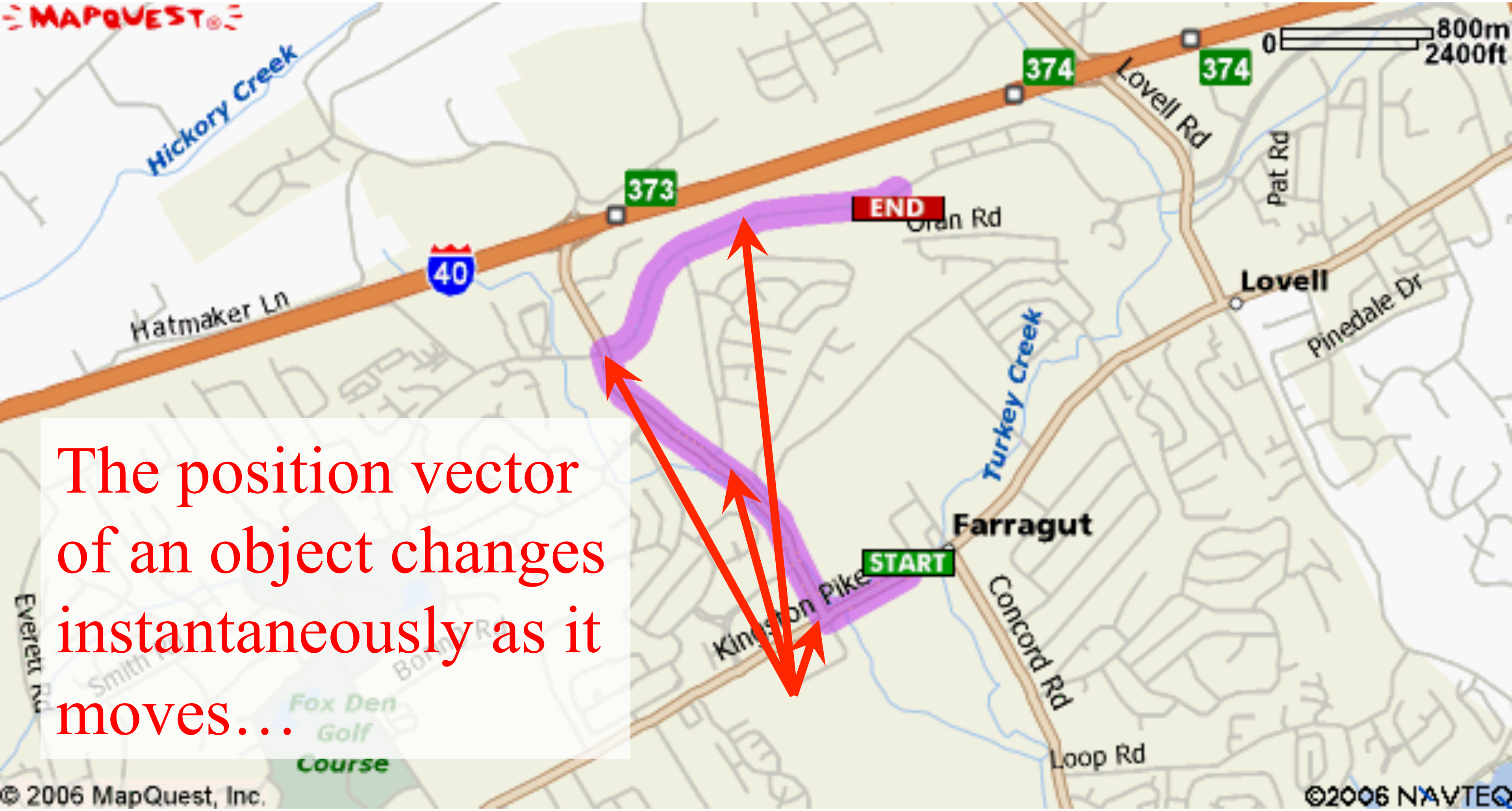
FHS to the Pinnacle

A "position" vector points to an object from a convenient well-known reference location:



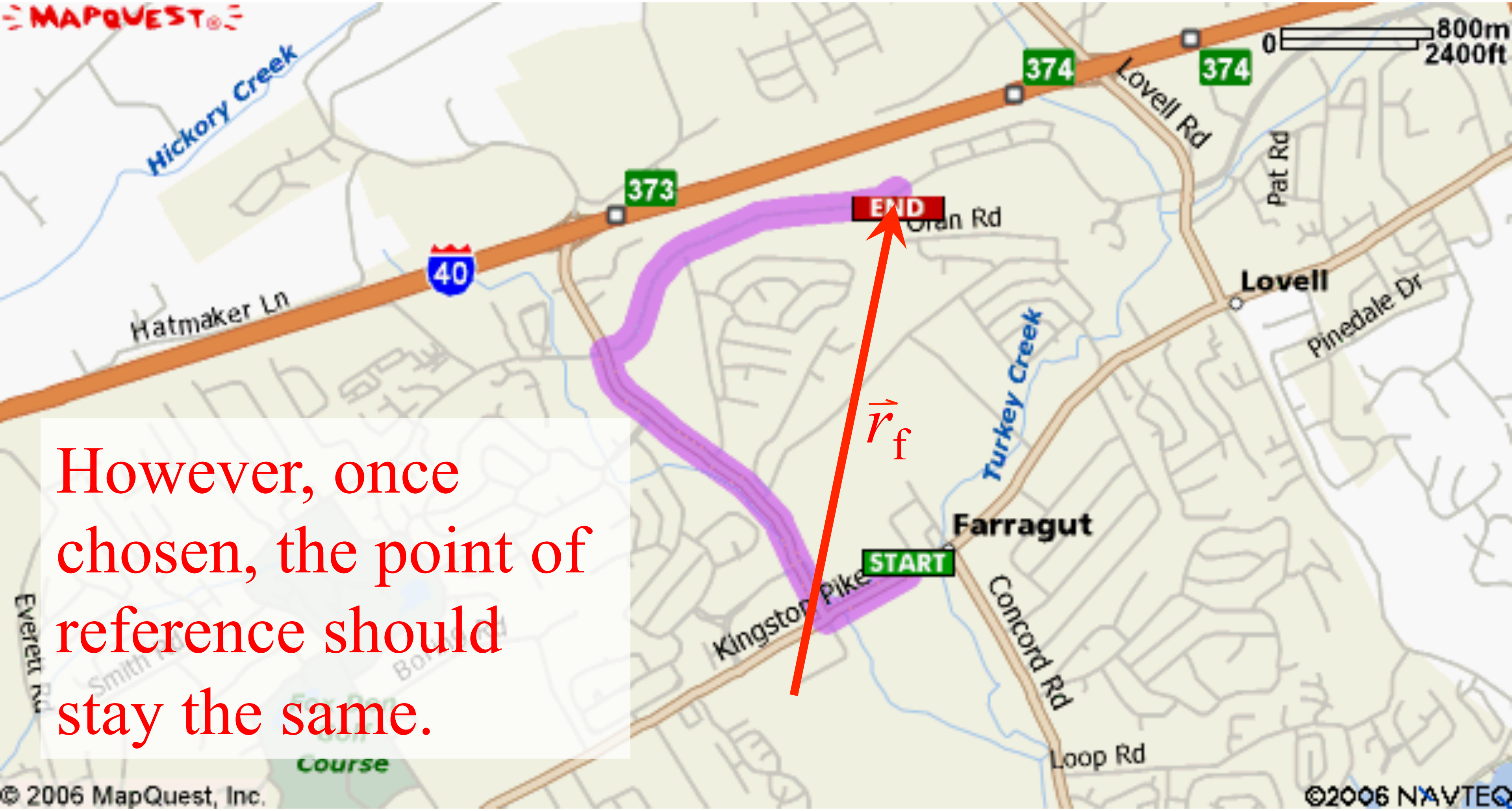
initial position = 500 m, 49° from town hall

FHS to the Pinnacle



The position vector of an object changes instantaneously as it moves…

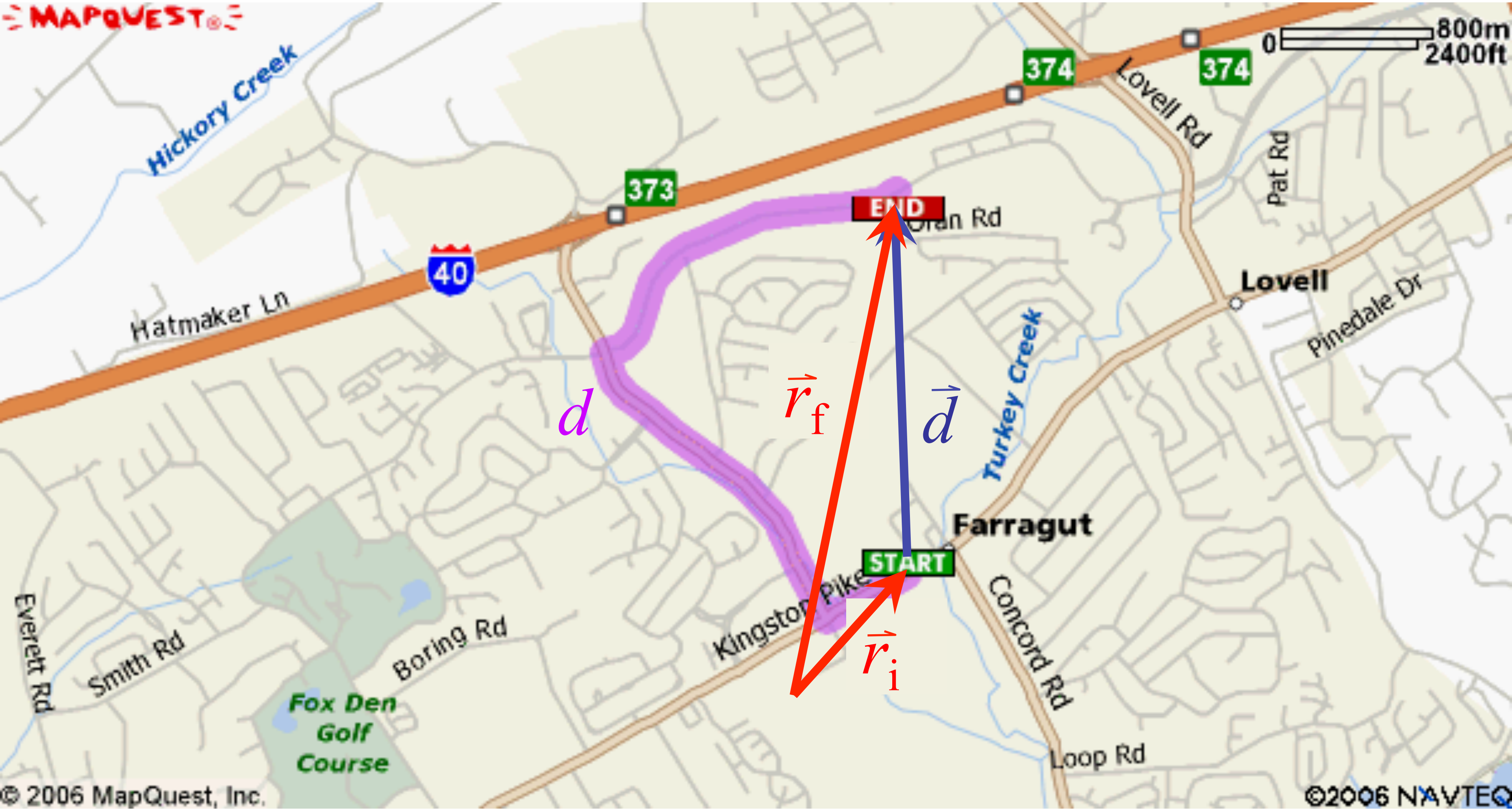
FHS to the Pinnacle



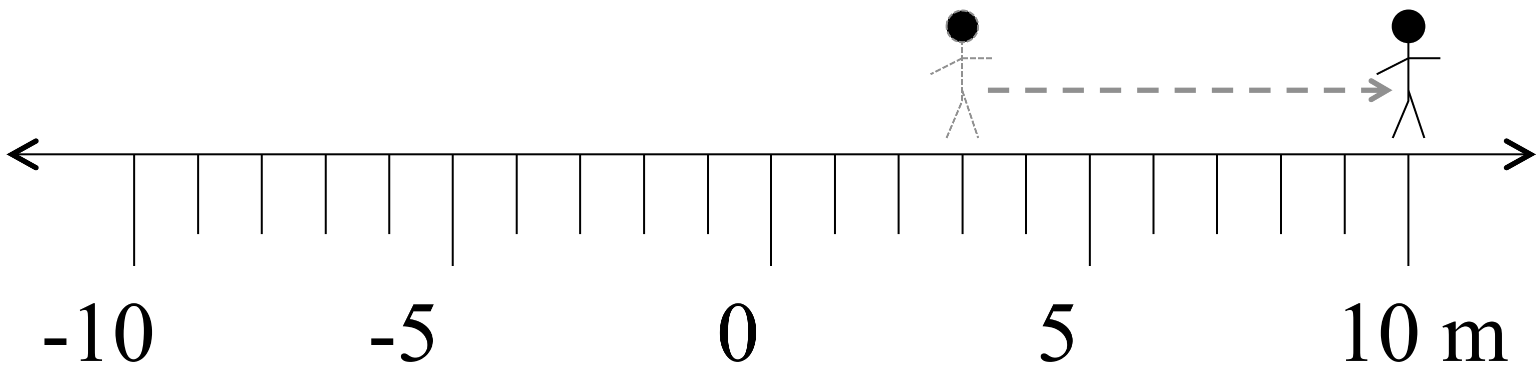
However, once chosen, the point of reference should stay the same.

final position = 2240 m, 83° from town hall

FHS to the Pinnacle

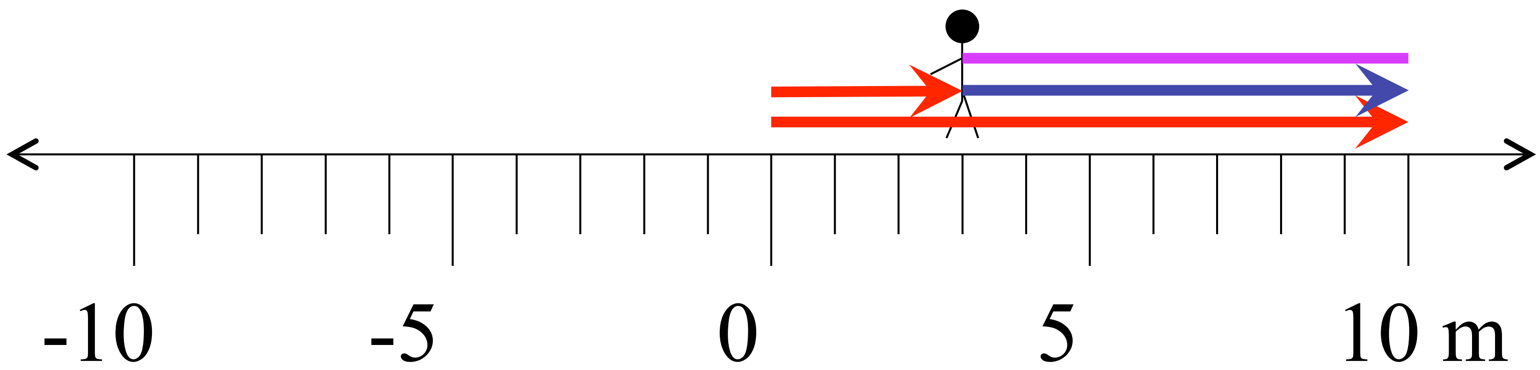


distance, displacement, initial and final positions



Consider one-dimensional motion (*i.e.* linear motion) of a person that walks along a number line from the 3 meter mark to the 10 meter mark.

How would this motion be described and quantified with the concepts position, displacement, distance?

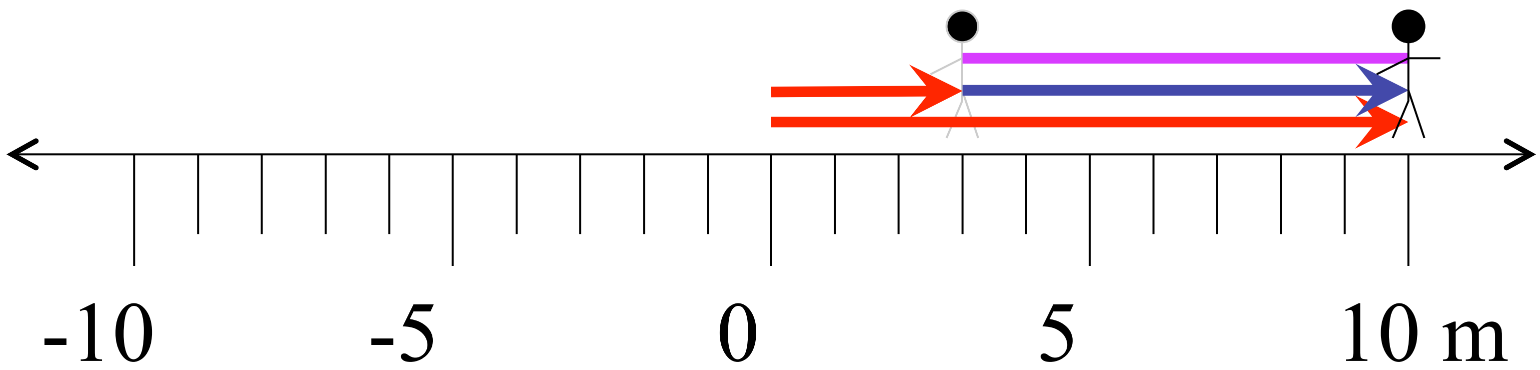


initial position, $\vec{x}_i = 3$ m, 0°

final position, $\vec{x}_f = 10$ m, 0°

displacement, $\vec{d} = 7$ m, 0°

distance, $d = 7$ m

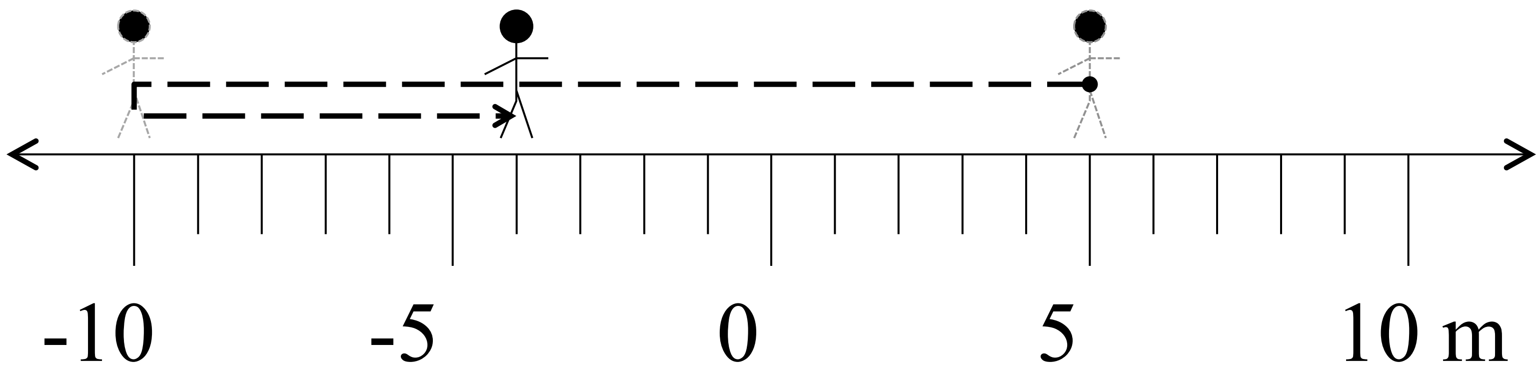


Notice: 10 – 3 = 7 m

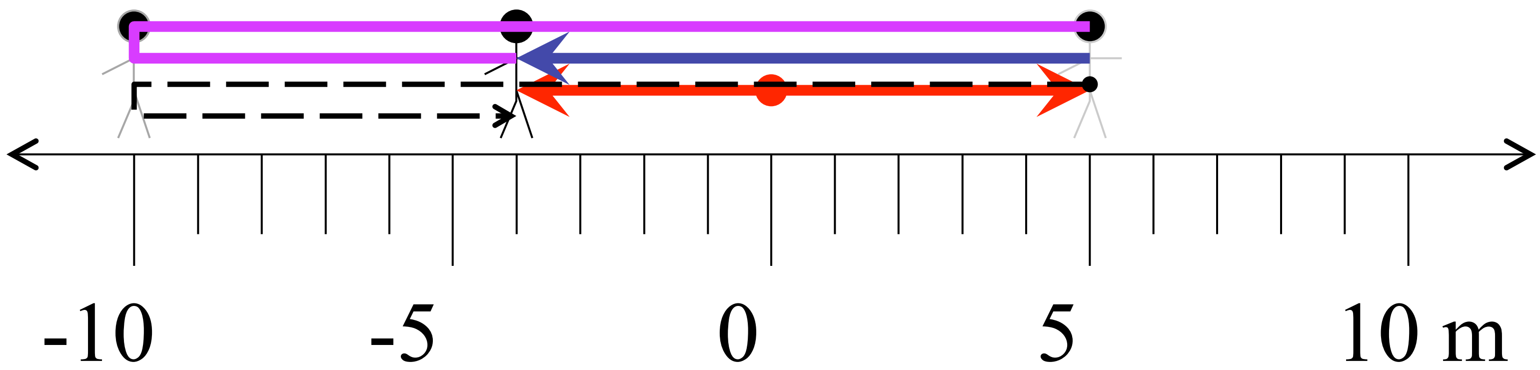
therefore: $$\vec{d} = \Delta \vec{x} = \vec{x}_f - \vec{x}_i$$

This is an equation that is equivalent to the word definition stating that displacement is equal to change in position.

Now suppose our man starts at the 5 m mark, runs to the -10 m mark, then strolls back to the -4 m mark:



Find: initial and final position, displacement, and distance.

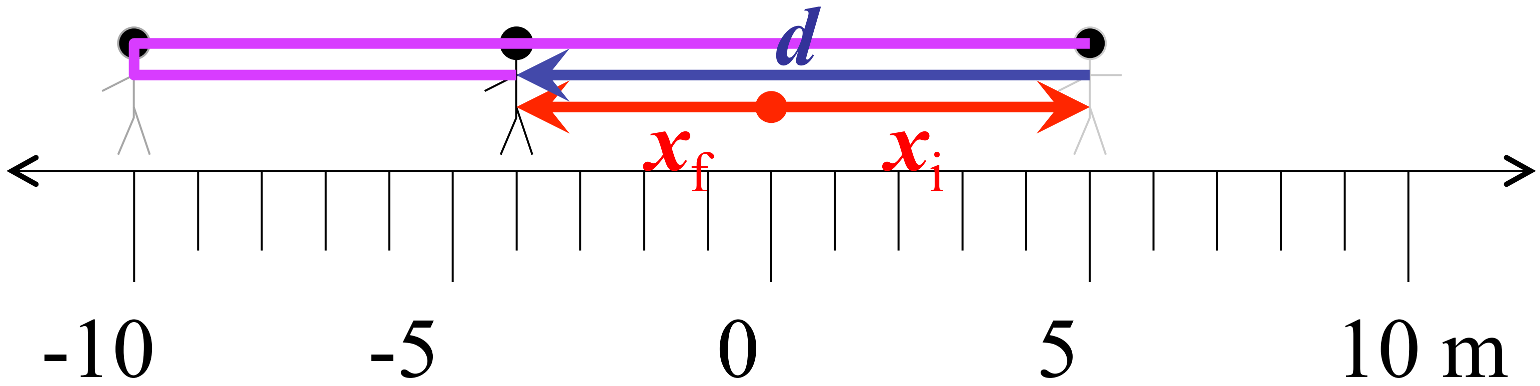


initial position, $\vec{x}_i = 5$ m, 0º

final position, $\vec{x}_f = 4$ m, 180º

displacement, $\vec{d} = 9$ m, 180º

distance, $d = 21$ m



Note that the equation works here so long as a negative value represents a left pointing vector. **Opposite pointing vectors are negative values mathematically!**

$$\vec{d} = \Delta\vec{x} = \vec{x}_f - \vec{x}_i$$

$$\vec{d} = \Delta\vec{x} = (-4) - 5$$

$$\vec{d} = \Delta\vec{x} = -9$$

$$\vec{d} = 9\text{ m}, 180°$$