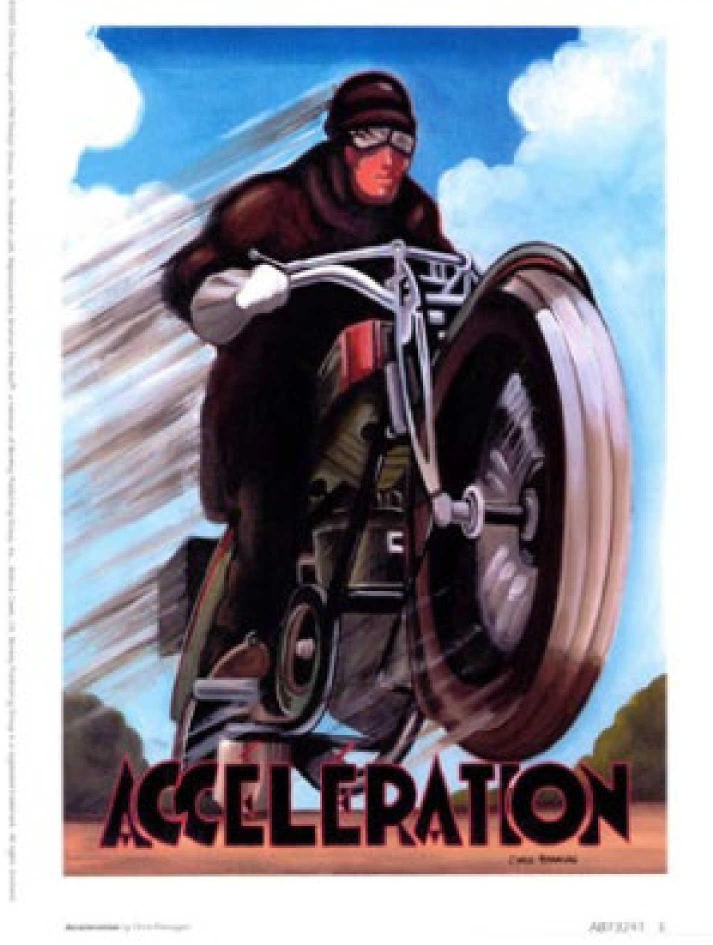
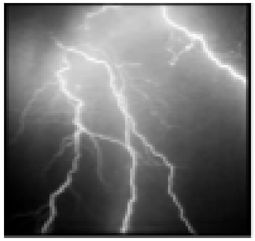
Acceleration, Uniform Accelerated Motion, Average and Instantaneous Acceleration



Review:

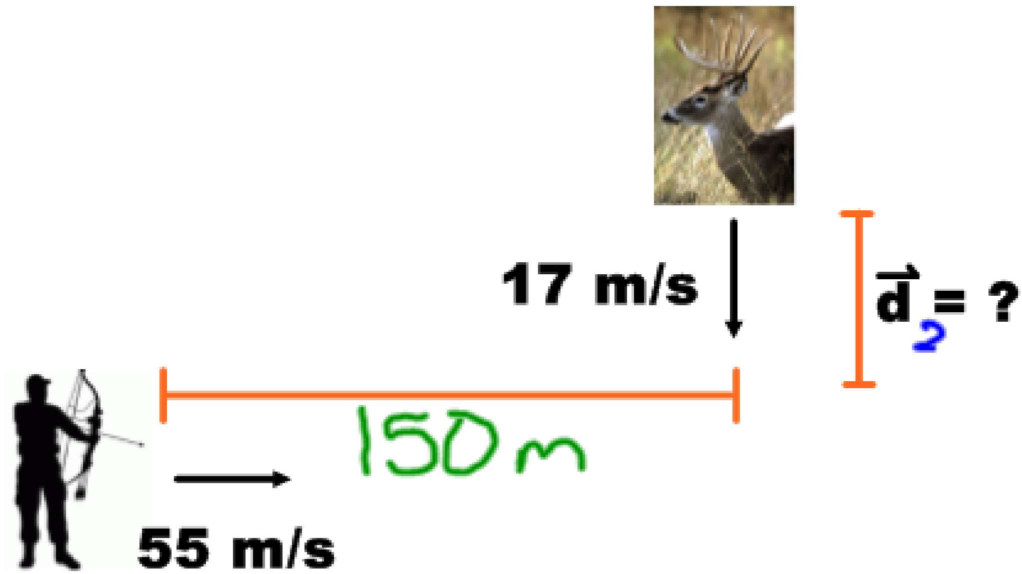
ex) A bolt of lightning is observed and the thunder is heard 5.25 s later. Given that the speed of sound is 343 m/s, how far away was the lightning bolt?



Secret Lightning Thing

***Rearrange your formula first!**

ex) An arrow is fired at 55 m/s E at a target moving at 17 m/s S. How far ahead of the target's starting position should the arrow be fired in order to hit it?



$\vec{v}_A = 55\ m/s,\ E = 55\ m/s$

$\vec{v}_D = 17\ m/s,\ S = -17\ m/s$

$t_A = ?$ $\Rightarrow t_A = t_D$

$t_D = ?$

$\vec{d}_1 = 150\ m$

$\vec{d}_2 = ?$

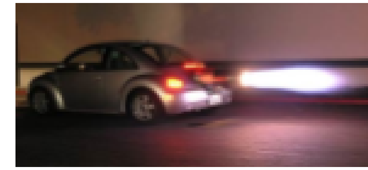
***Make a variables list**

*** $t_{arrow} = t_{target}$**

Ans: [redacted]


Secret Tree Stand Thing

ex) Two cars compete in a 1000 m race. Car A travels at 175 m/s, car B at 182 m/s. When the faster car finishes, how far behind, in m, is the slower car?



Secret Rocket-Beetle Thing

$d_B = 1000\,m$

$d_A = ?$

$V_B = 182\,\frac{m}{s}$

$V_A = 175\,\frac{m}{s}$

$t_A = ?$

$t_B = ?$

$$t_B = \frac{d_B}{V_B} = \frac{1000\,m}{182\,m/s} = 5.49\,s$$

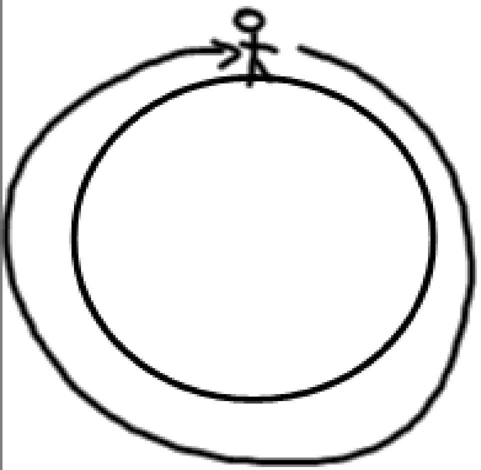
$$t_A = 5.49\,s$$

$$d_A = V_A t_A = 175\,\frac{m}{s}(5.49\,s) = 961\,m$$

$$d_{between} = 1000\,m - 961\,m = 38.5\,m$$

Ans:

ex) Given that the diameter of the Earth is 12.7×10^6 m, how fast is the planet rotating (in m/s)?



Secret Earth Thing

***The Earth rotates once per day.**

***C = πd**

$$C = \pi d$$

$$= \pi(12.7 \times 10^6 m)$$

$$t = 24h \times \frac{3600s}{h}$$

$$= 86\,400s$$

$$V = \frac{C}{t} = \frac{\pi(12.7 \times 10^6 m)}{86\,400s}$$

$$= 462 \frac{m}{s}$$

Non-uniform motion = accelerated motion

We have talked about uniform motion (a body at rest or moving at a constant velocity). But what happens if the velocity changes? We get an acceleration.

Acceleration

-While we can not sense a constant velocity, we can sense a change in velocity.

Acceleration is the rate of change of velocity.

$$\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$$

Where:

$\vec{a}$ = acceleration
$\vec{v}$ = velocity
t = time

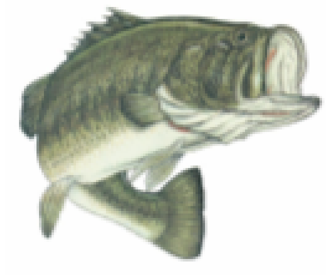
What are the units of $\vec{a}$?

- This can be determined through unit analysis.

$$\vec{a} = \frac{\Delta \vec{v}}{\Delta t} = \frac{(m/s)}{(s)} = \frac{m}{s \times s} = \frac{m}{s^2}$$

The unit of acceleration is metre per second squared (m/s^2)

ex) A bass begins to swim left at 5.00 m/s. 5.0 minutes later, the bass has increased its velocity to 7.00 m/s. What was the animal's acceleration over this time?



$t = 5.0\,\text{min}$

$= 300\,\text{s}$

$\vec{a} = \dfrac{\Delta \vec{V}}{t}$

$\vec{V}_1 = 5.00\,\frac{m}{s}$ left

$\vec{V}_2 = 7.00\,\frac{m}{s}$ left

$= \dfrac{\vec{V}_2 - \vec{V}_1}{t} = \dfrac{7.00\,\frac{m}{s} - 5.00\,\frac{m}{s}}{300\,s}$

$= \dfrac{2.00\,m/s}{300\,s} = 6.7 \times 10^{-3}\,\frac{m}{s^2}$

left

Ans:

ex) While driving at 100 km/h, I spied a student on the road and hits the brakes. It takes 98 m to stop my car. What was the acceleration of the car?

$\vec{a} = \frac{\vec{v}}{t}$ $\vec{v} = \frac{\vec{d}}{t}$

*Convert to m/s from km/h by dividing by 3.6!

$\vec{v}_1 = 100 \frac{km}{h}$

$\vec{d} = 98 m$

$\vec{a} = ?$

$\vec{v}_2 = 0 \frac{km}{h}$

$\vec{t} = ?$

$t = \frac{\vec{d}}{\Delta \vec{v}} = \frac{0.098 km}{0 \frac{km}{h} - 100 \frac{km}{h}}$

$= \frac{0.098 km}{-100 \frac{km}{h}}$

$= {}^{-}0.00098 h$

$\vec{a} = \frac{-100 \frac{km}{h}}{0.00098 h}$

$= 102\ 041 \frac{km}{h^2}$

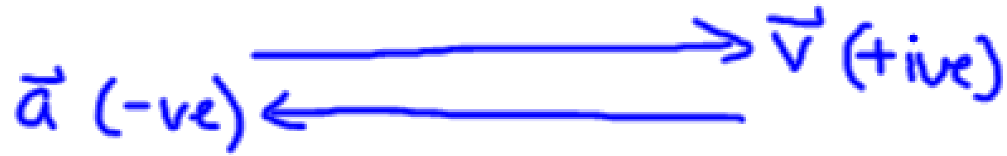
$= {}^{-}1.0 \times 10^5 km/h^2$

deceleration

Ans: [redacted]

Negative Acceleration vs Deceleration

Note that our last answer was negative. What does that mean?



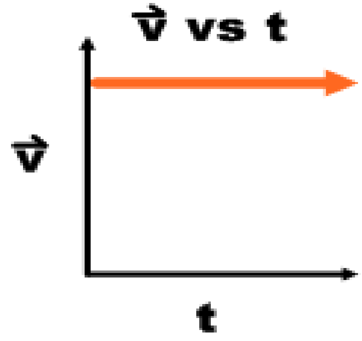
In this last case, the direction of the velocity was positive, and the acceleration was negative. Because the two were in opposite directions, the car slowed down. This is called deceleration.

If $\vec{v}$ and $\vec{a}$ are in same direction (same signs) = acceleration.

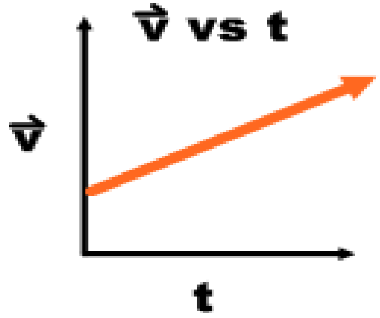
If $\vec{v}$ and $\vec{a}$ are in opposite directions (opposite signs) = deceleration.

Graphing Acceleration

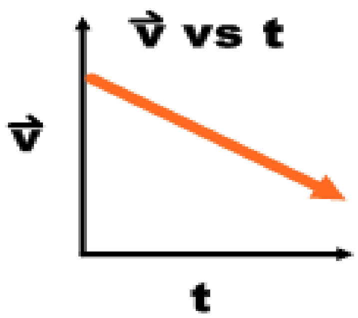
Acceleration can be found from the slope of a velocity vs. time graph.



-This represents zero acceleration, or constant velocity, as the slope is zero.

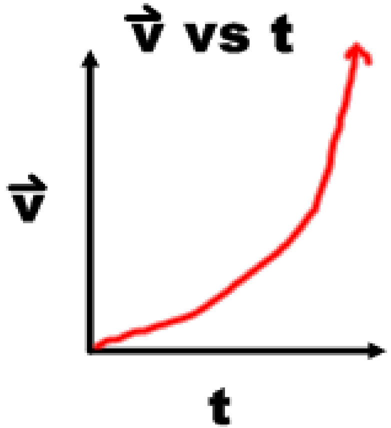


- This represents a constant acceleration. Velocity increases at a constant rate as time increases.



-This represents a deceleration, as the slope of the line is negative.

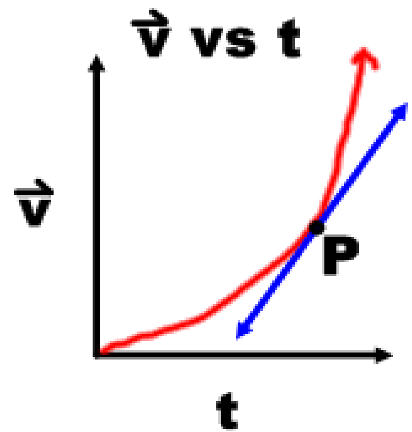
Non-uniform Acceleration



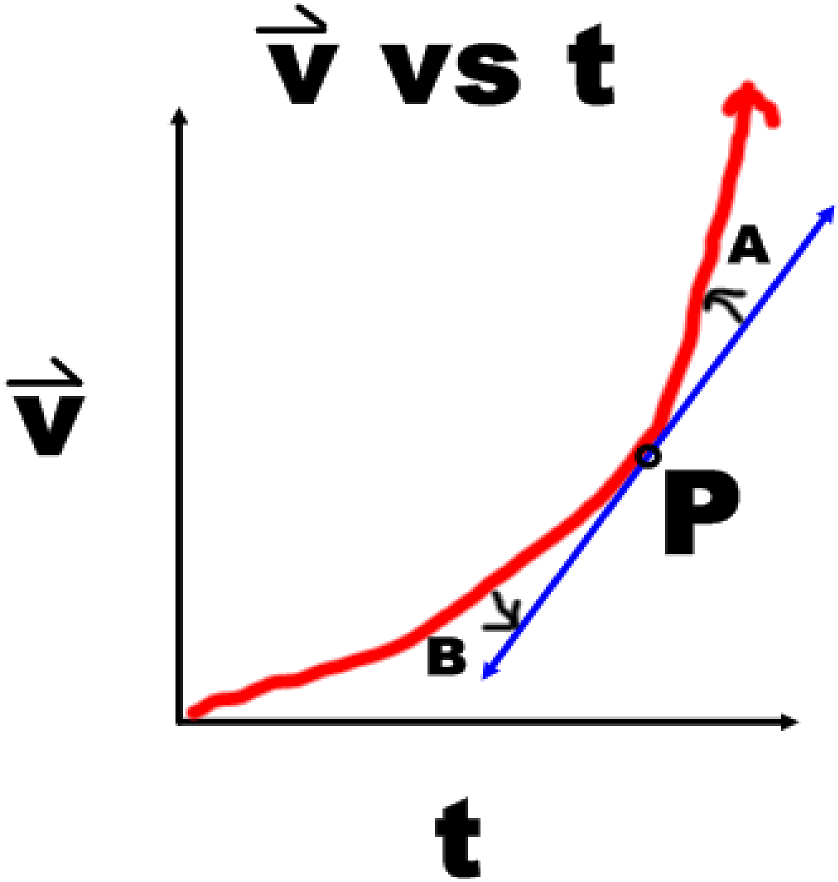
☆

-This is a graph where acceleration is <u>not</u> constant.

To find the acceleration of the graph at any given point P, we will draw a tangent line then find the slope of this new line.



This will give <u>instantaneous acceleration.</u>



***Note:**

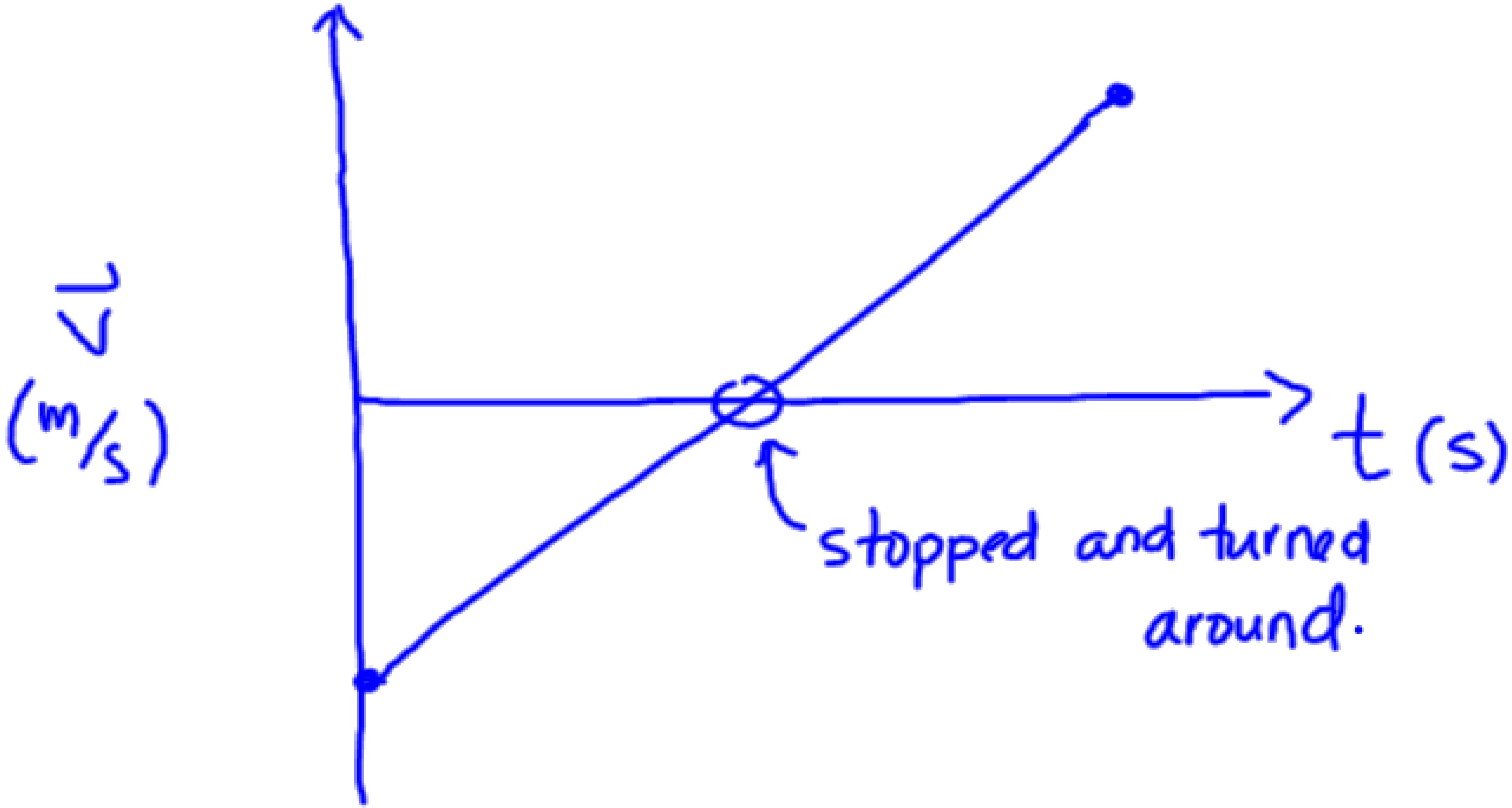
When drawing tangents, the angle A should roughly equal the angle B.

Here's an example outlining average acceleration.

ex) A car is backing down a hill at -3.0 m/s. After 2.50 s, the car starts moving forward at +4.5 m/s.

a) What is the car's average acceleration?

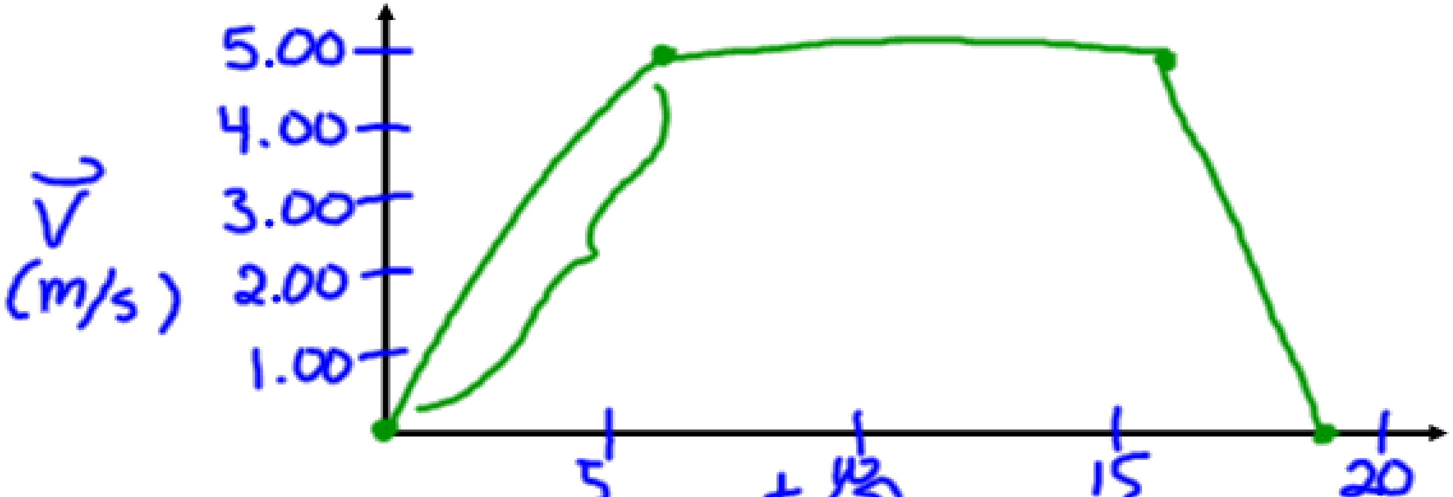
b) Sketch the $\vec{v}$ vs. t graph for this motion (no #'s).



$\vec{v}$ (m/s)
t (s)
stopped and turned around.

ex) A cyclist, starting from rest, bikes with a constant acceleration for 6.0 s until she reaches 5.00 m/s. Then she coasts with a constant velocity for 10.0 s before slowing for 2.0 s to 0.0 m/s.

a) Sketch a graph of the cyclist's motion (with #'s).



b) What is the average acceleration b/t 0.0 - 6.0 s?

$$\vec{a} = \frac{\vec{v}_2 - \vec{v}_1}{\Delta t} = \frac{5.00\,m/s - 0\,m/s}{6.0\,s} = \frac{5.00\,m/s}{6.0\,s} = 0.83\,m/s^2$$

c) What is the acceleration at 10.0 s?

More Acceleration Problems:

We often use the form:

$$\vec{a} = \frac{\vec{v}_f - \vec{v}_i}{t}$$

As we often deal with the final and initial velocities of an object.

This form can be manipulated as follows:

$$t = \frac{\vec{v}_f - \vec{v}_i}{\vec{a}} \qquad \vec{v}_f = \vec{v}_i + \vec{a}t \qquad \vec{v}_i = \vec{v}_f - \vec{a}t$$

ex) An insect buzzes at 3.0 m/s, then accelerates for 4.75 s at 1.25 m/s^2. What is the insect's final velocity?

Ans: 8.9 m/s

ex) An electron has a final velocity of 3.0×10^6 m/s after accelerating for 25 s at 1.5×10^4 m/s^2. What was the electron's initial velocity?

Ans: 2.6×10^6 m/s