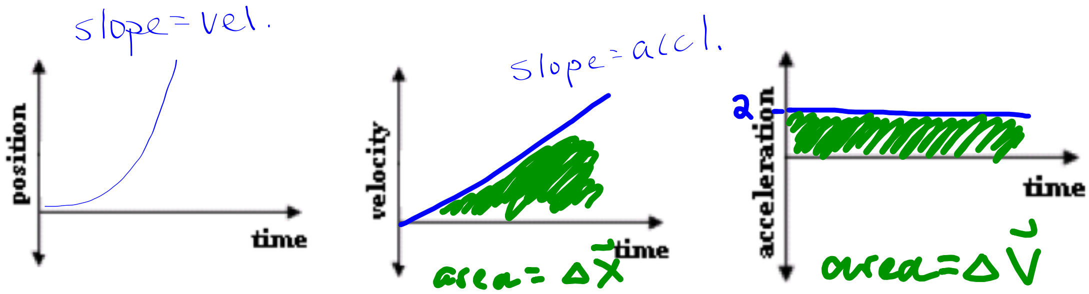
3. Use the chart you just filled in to sketch the following graphs of motion for the cart.



4. What is the relationship between position and time?

Square

5. What is the relationship between velocity and time?

direct

6. What is the relationship between acceleration and time?

constant

Uniform acceleration:

constant accl (includes zero)

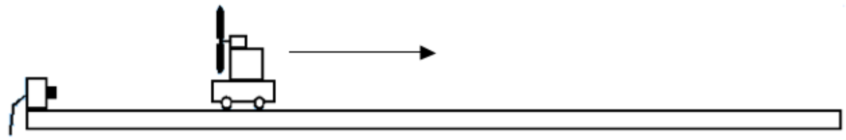
7. What is the meaning of the slope of the velocity-time graph?

8. What is the meaning of the area under the velocity-time graph?

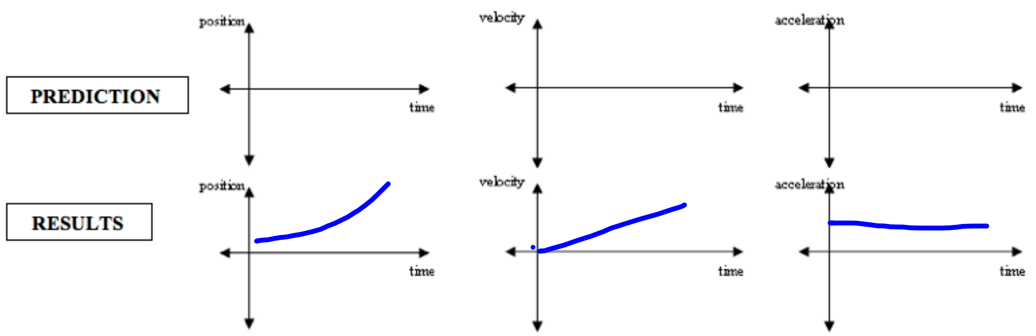
9. What is the meaning of the slope of the position-time graph?

Graphs of Accelerated Motion

DEMO #1



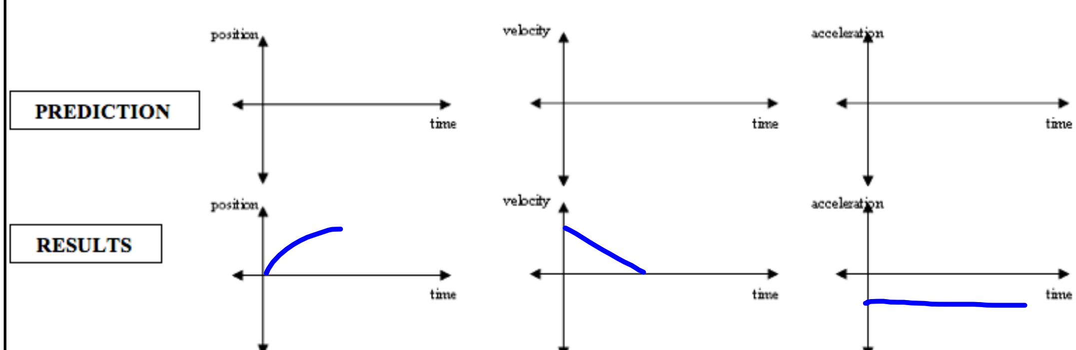
Sketch below your predictions and the results for the fan-cart moving **away** from the detector and **speeding up** at a steady rate.



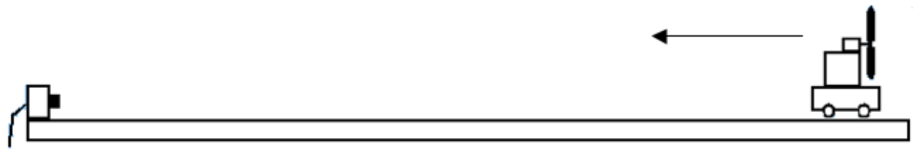
1. What is the significance of the slope of the velocity-time graph?

DEMO #2

Sketch below your predictions and the results for the fan-cart moving **away** from the detector and **slowing down** at a steady rate.



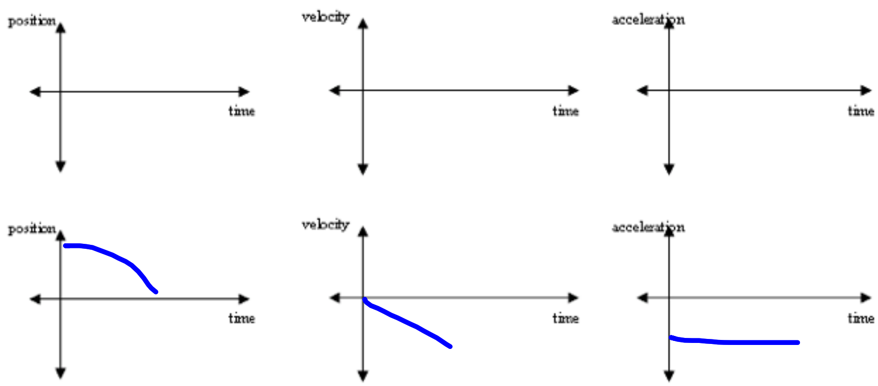
DEMO #3



Sketch below your predictions and the results for the fan-cart moving **towards** the detector and **speeding up** at a steady rate.

PREDICTION

RESULTS

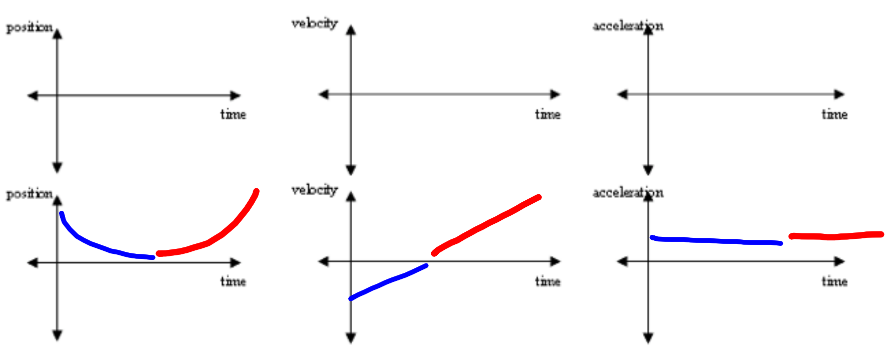


DEMO #4

Sketch below your predictions and the results for the fan-cart moving **towards** the detector and **slowing down** at a steady rate.

PREDICTION

RESULTS



2. Complete the following chart by looking back over the four demos to determine which carts:

Were moving in a positive direction	Were moving in a negative direction	Had a positive velocity	Had a negative velocity	Were speeding up	Were slowing down	Had a positive acceleration	Had a negative acceleration
1,2	3,4	1,2	3,4	1,3	2,4	1,4	2,3

3. What does it mean for the cart to have a positive velocity?

   moving in + direction

4. What does it mean for the cart to have a negative velocity?

   moving in - direction

5. What does it mean for the cart to have a positive acceleration?

   velocity is increasing

6. If the cart has a positive acceleration, does it have to be speeding up (going faster)?

   not necessarily

7. What does it mean for the cart to have a negative acceleration?

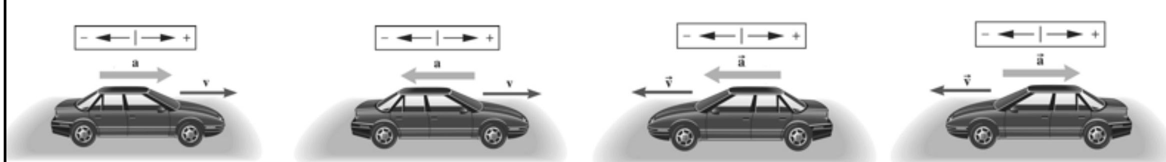
   velocity is decreasing

8. If the cart has a negative acceleration, does it have to be slowing down (going slower)?

   not necessarily

   deceleration: *speed* decreasing

9. In each case below, decide whether the car is speeding up or slowing down.



↑ ↓ ↑ ↓

10. Compare the car's velocity and its acceleration when it is speeding up. $\vec{v} \parallel \vec{a}$

11. Compare the car's velocity and its acceleration when it is slowing down. $\vec{v}$ opposite $\vec{a}$

Acceleration

Acceleration:

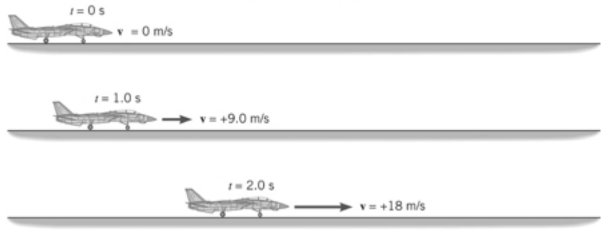
rate of change of velocity

Formula: $\vec{a} = \frac{\Delta \vec{V}}{t}$

Units: $[m/s^2]$

Type: vector

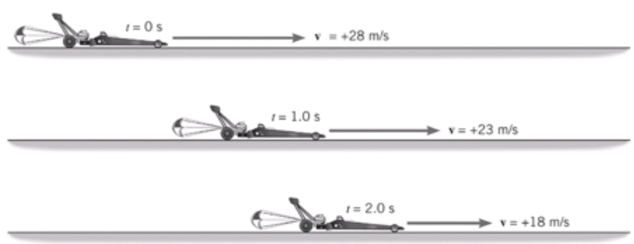
1. Calculate the acceleration of the plane.



$$\vec{a} = \frac{\vec{V}_f - \vec{V}_0}{t} = \frac{18\,m/s - 0}{2\,s}$$

$$= +9\,m/s^2$$

2. Calculate the acceleration of the racecar.



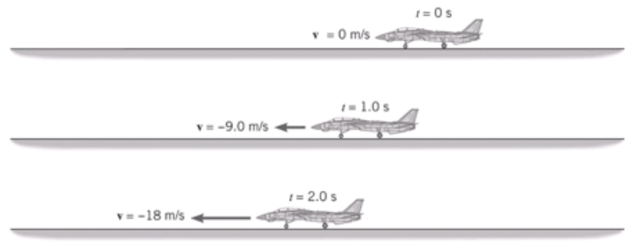
$$\vec{a} = \frac{\vec{V}_f - \vec{V}_0}{t} = \frac{18\,m/s - 23\,m/s}{1\,s}$$

$$= -5\,m/s^2$$

If an object has a negative acceleration, does that mean it is decelerating?

negative acceleration: velocity decreasing

3. Calculate the acceleration of the plane.



$$\vec{a} = \frac{\vec{v}_f - \vec{v}_0}{t} = \frac{-18\,m/s - 0}{2\,s}$$

$$= -9\,m/s^2$$

Can an object have a negative acceleration and be speeding up?

10

Turning

1. What are the three ways an object can accelerate?
   a) speeding up
   b) slowing
   c) turning
2. Can a car have a constant speed and be accelerating?
   yes, if direction changing
3. Can a car have a constant velocity and be accelerating?
   no
4. Is it possible for a car to have velocity but no acceleration? Explain and give an example.
   driving in straight line, without changing speed
5. Is it possible for a car to have acceleration but no velocity? Explain and give an example.
   yes, at instant of changing direction

Kinematics Equations The 'Big 4'

$\vec{v}_{avg} = \frac{\vec{d}}{t}$ → $\vec{d} = \vec{v}_{avg} \cdot t = \frac{v_f + v_0}{2} \cdot \frac{v_f - v_0}{a}$

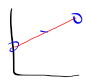
$\vec{d} = \frac{\vec{v}_f^{\,2} - \vec{v}_0^{\,2}}{2a}$ → $v_f^2 = v_0^2 + 2ad$

$\vec{a}_{avg} = \frac{\Delta \vec{v}}{t}$ → $\vec{v}_f = \vec{v}_0 + \vec{a}t$

$\frac{\vec{d}}{t} = \frac{\vec{v}_f + \vec{v}_0}{2}$

$\vec{d} = \frac{\vec{v}_f + \vec{v}_0}{2} \cdot t$

a is const



$\vec{v}_{avg} = \frac{\vec{v}_f + \vec{v}_0}{2}$

$\vec{d} = \frac{v_f + v_0}{2} \cdot t$

$= \left(\frac{(v_0 + at) + v_0}{2}\right) \cdot t = \frac{2v_0 t + at^2}{2}$

$\vec{d} = \vec{v}_0 t + \frac{1}{2}\vec{a}t^2$

v_0
d
v_f
a
t

6. A motorcycle traveling at 12.6 m/s accelerates at a rate of 1.7 m/s^2 for 3.4 seconds. What is its final velocity?

7. A bullet is accelerated from rest at a rate of 400 m/s^2 for 0.05 seconds. How far did it travel while it was accelerating?

8. An elephant accelerates from 5.0 m/s to 10. m/s at a rate of 2.0 m/s^2. What is the elephant's final displacement?