Acceleration

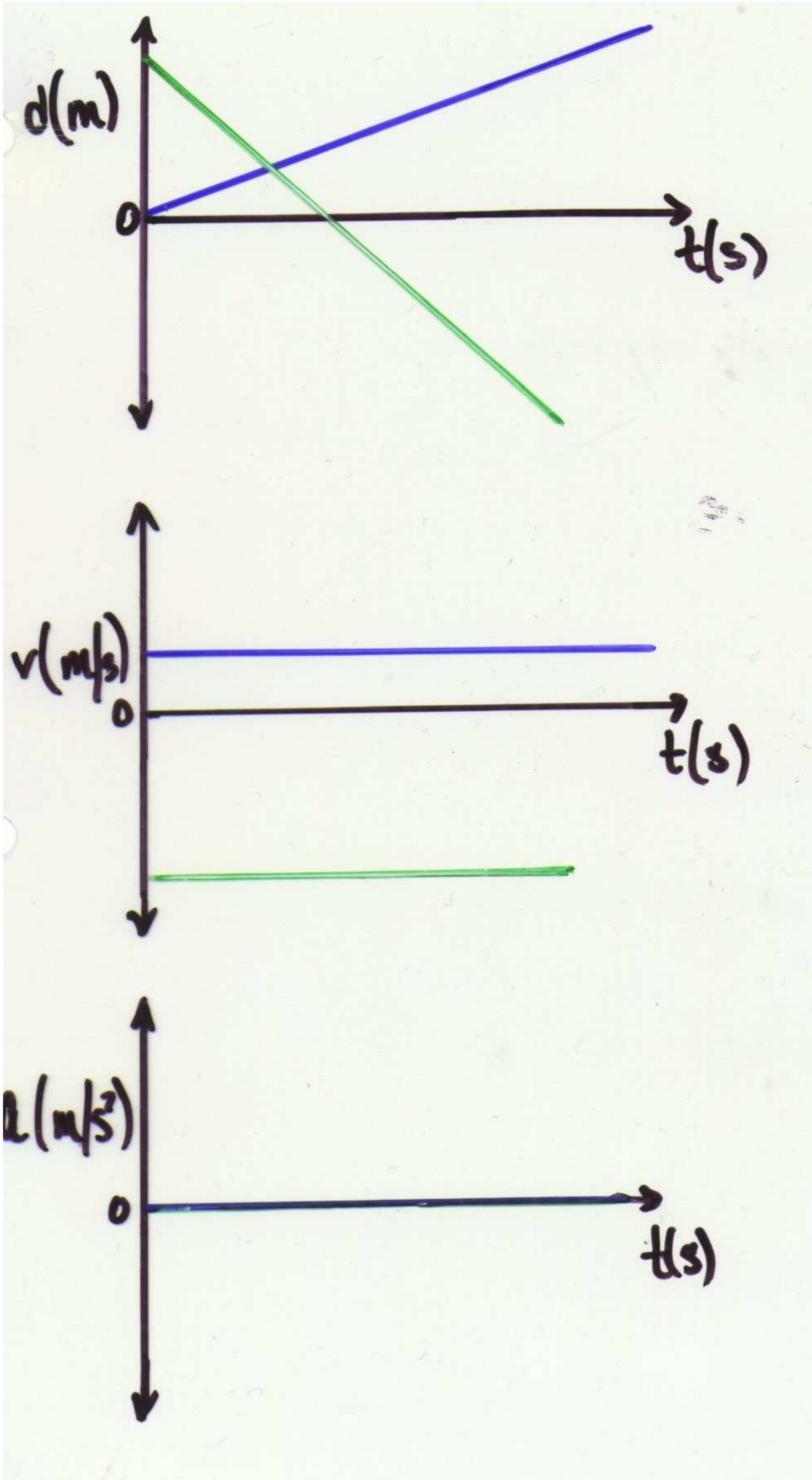
- acceleration tells us how fast the velocity changes whereas velocity tells us how fast the position changes.

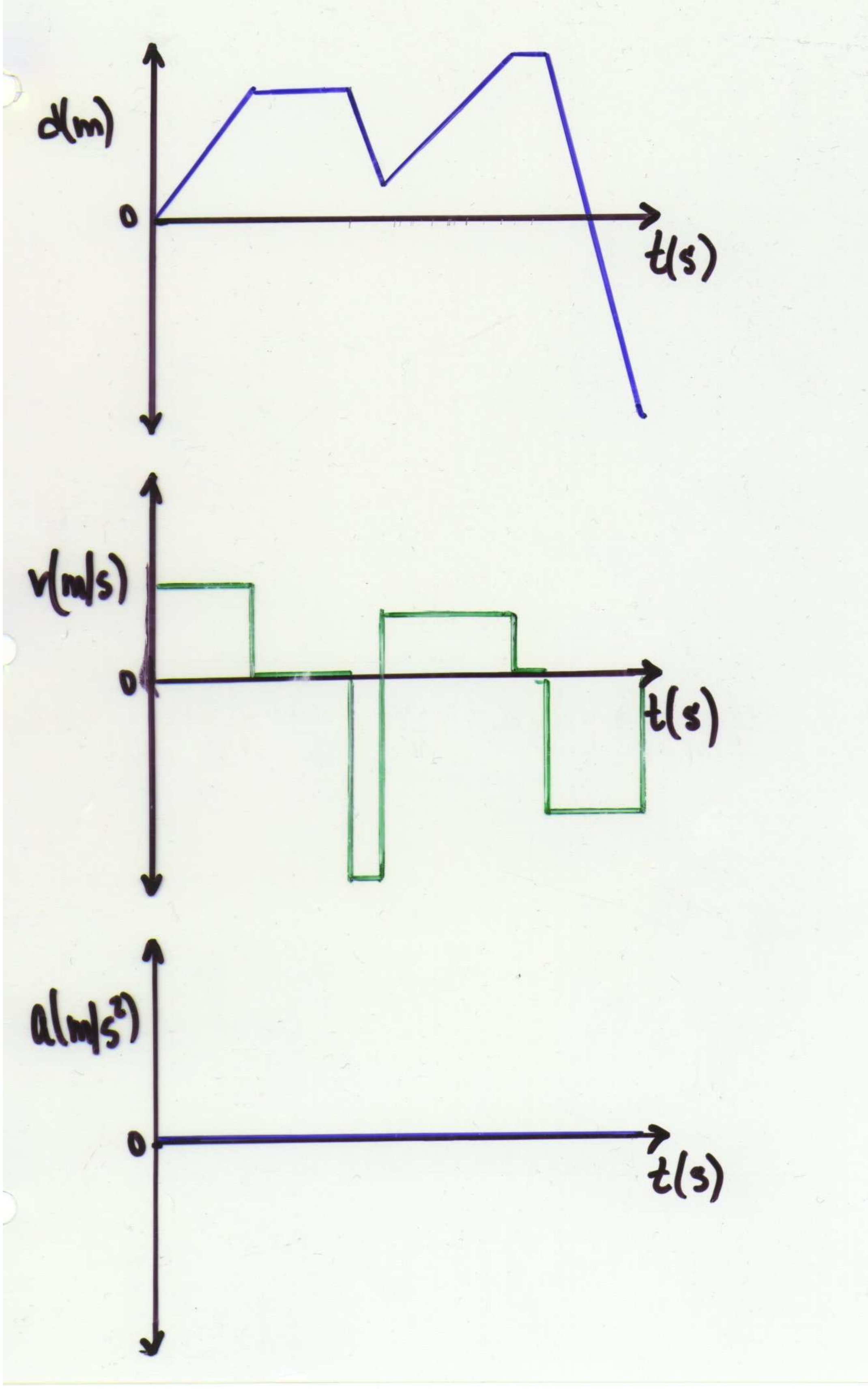
- acceleration is a vector quantity.

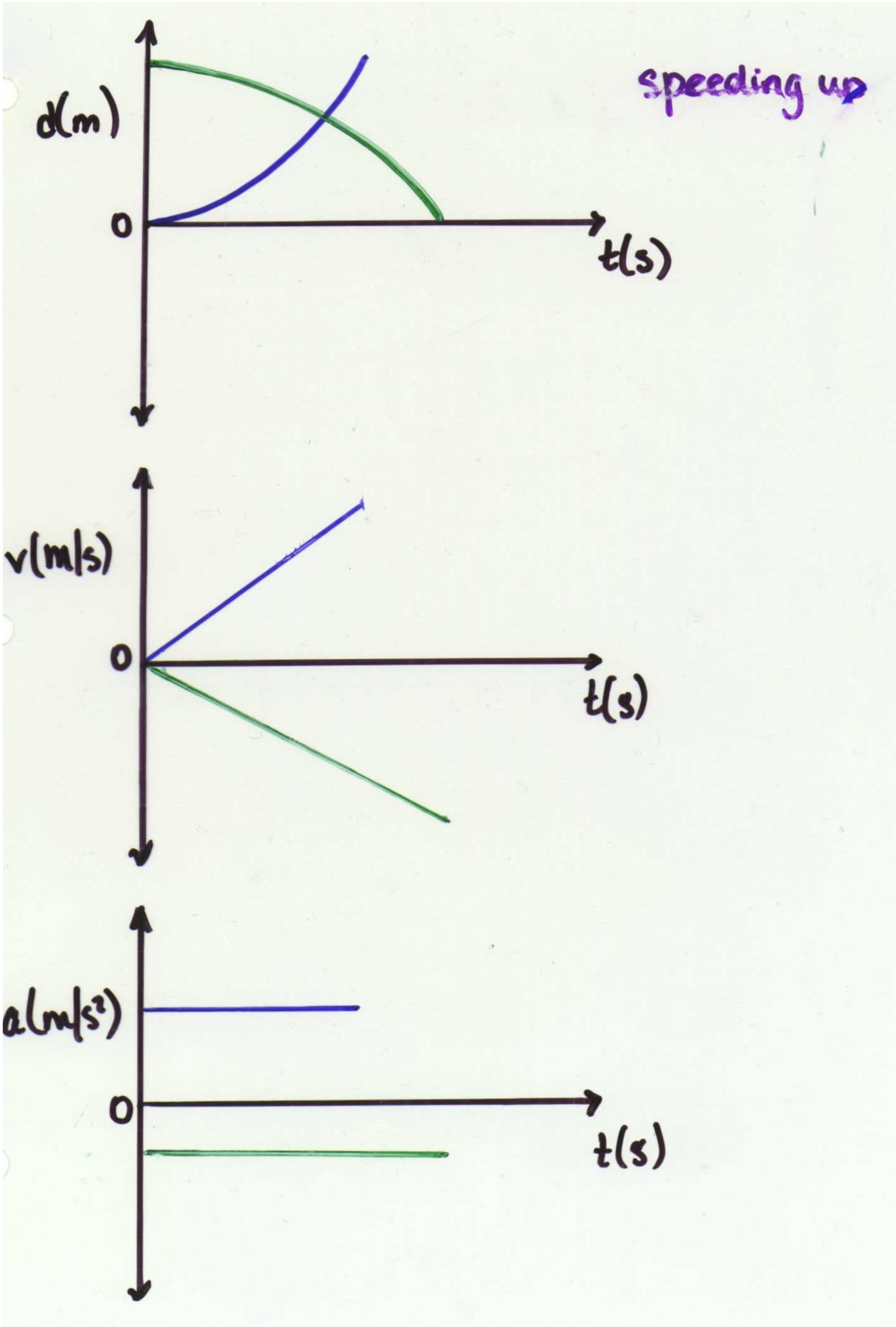
- average acceleration is the ratio of the change in velocity to the time interval in which it changes.

$$a = \Delta v/\Delta t$$

***if you are accelerating, you cannot have a constant velocity!!

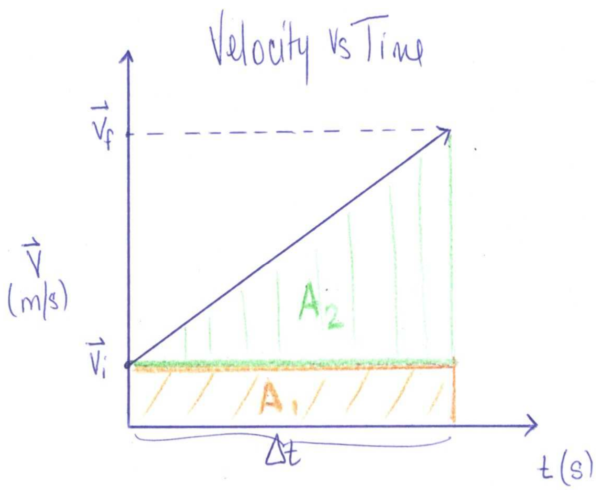

d(m)
0
t(s)
v(m/s)
0
t(s)
a(m/s²)
0
t(s)


d(m)
0
t(s)
v(m/s)
0
t(s)
a(m/s²)
0
t(s)


speeding up
d(m)
0
t(s)
v(m/s)
0
t(s)
a(m/s²)
0
t(s)

Derivation of Equations for Accelerated Motion

formula	v_i	v_f	d	a	t
1 $v_f = v_i + at$	✓	✓		✓	✓
2 $d = \frac{1}{2}(v_f + v_i)t$	✓	✓	✓		✓
3 $d = v_i t + \frac{1}{2}at^2$	✓		✓	✓	✓
4 $v_f^2 = v_i^2 + 2ad$	✓	✓	✓	✓	



Area 2 = ½ base * height

Area 1 = length * width

Equation 1:

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

$$a = \frac{v_f - v_i}{\Delta t}$$

$$a \Delta t = v_f - v_i$$

$$v_f = v_i + at$$

Equation 2:

Displacement is the area under the curve

$$d = Area\ 1 + area\ 2$$

$$d = lw + \tfrac{1}{2}bh$$

$$d = v_i t + \tfrac{1}{2}(v_f - v_i)t$$

$$d = v_i t + \tfrac{1}{2}v_f t - \tfrac{1}{2}v_i t$$

$$d = \tfrac{1}{2}v_i t + \tfrac{1}{2}v_f t$$

$$d = \tfrac{1}{2}(v_f + v_i)t$$

Equation 3:

Substitute equation 1 into equation 2

$$d = \tfrac{1}{2}(v_f + v_i)t$$

$$v_f = v_i + at$$

$$d = \tfrac{1}{2}[(v_i + at) + v_i]t$$

$$d = \tfrac{1}{2}[2v_i + at]t$$

$$d = v_i t + \tfrac{1}{2}at^2$$

Equation 4:
Substitute equation 1 into equation 2

$$d = \tfrac{1}{2}(v_f + v_i)t$$

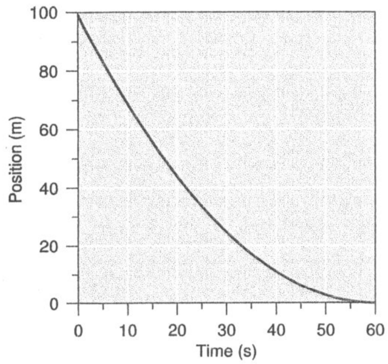
$$v_f = v_i + at$$

$$d = [\tfrac{1}{2}(v_f + v_i)][\frac{v_f - v_i}{a}]$$

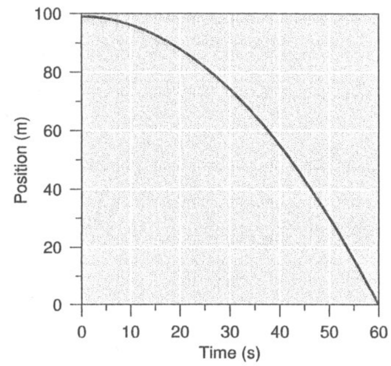
$$2ad = [v_f + v_i][v_f - v_i]$$

$$2ad = v_f^2 - v_i^2$$

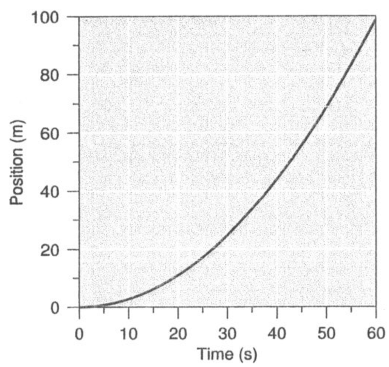
Negative Velocity : Positive Acceleration



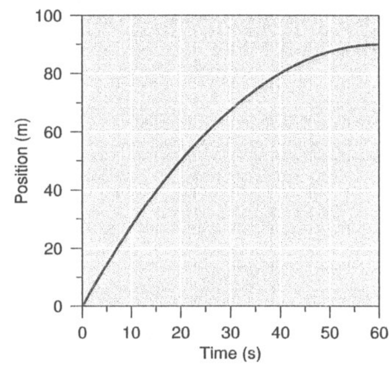
Negative Velocity : Negative Acceleration



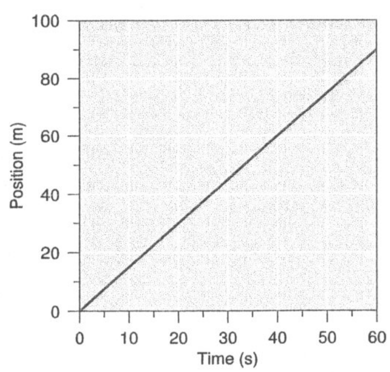
Positive Velocity : Positive Acceleration



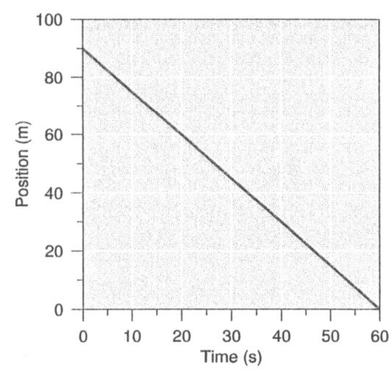
Positive Velocity : Negative Acceleration



Positive Constant Velocity



Negative Constant Velocity



Ex. 1 A car starts from rest and reaches a velocity of 40. m/s in 10. s.

A) What is its acceleration?

B) If its acceleration remains the same, what will its velocity be 5.0 s later?

Ex. 2 The brakes of a certain car produce an acceleration of 6.0 m/s^2.

A) How long does it take the car to come to a stop from a velocity of 30. m/s?

B) How far does the car travel during the time the brakes are applied?

Ex. 3 The brakes of a car whose initial velocity is 30. m/s are applied and the car receives an acceleration of -2.0 m/s^2.

A) How far will it have gone when its velocity has decreased to 15 m/s?

B) How far will it have gone when it has come to a stop?

Instantaneous Acceleration

- an object does not always move with a constant velocity.

  To find instantaneous acceleration on a velocity - time graph, draw a line that is tangent to the curve at that point. The slope is the instantaneous acceleration (take the two points on the tangent from each side of the point).

Acceleration Due to Gravity

- Galileo showed that all objects fall to Earth with a constant acceleration. No matter what the mass of the object is, or whether it is dropped or thrown, as long as air resistance can be ignored, the acceleration due to gravity is the same for all objects at the same location on Earth.

- acceleration $\Rightarrow g = 9.80\ m/s^2$

- acceleration is a vector quantity. The velocity of a falling object is a negative quantity and so is the acceleration of a falling object.

Ex. 1 The time the Demon Drop ride at Cedar Point, Ohio is freely falling is 1.5 s.

A) What is its velocity at the end of this time?

B) How far does it fall?

Ex. 2 A tennis ball is thrown straight up with an initial velocity of +22.5 m/s. It is caught at the same distance above ground from which it was thrown.

A) How high does the ball rise?

B) How long does the ball remain in the air?

Graphing

- the slope on a v-t graph gives acceleration.
- the area under the curve of an a-t graph is the velocity.