Name: _____

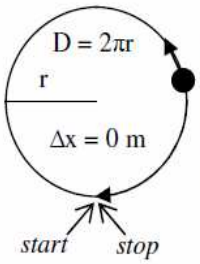
Period: _____

Kinematic Equations (R)

1.4

Displacement (Δx) in m

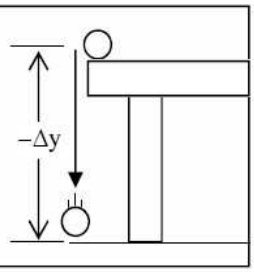
Distance (D) is how far an object has traveled. Displacement (Δx) is how far an object has moved from its original position. Displacement can be positive or negative.



An object that travels a circular path and ends up at its starting point has a distance equal to the circumference (2πr), but no displacement.

Vertical Displacement

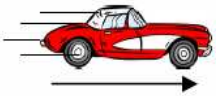
If an object moves up or down we use Δy, not Δx. Remember that down is negative (as is moving to the left for Δx).



Velocity (v) in m/s

Velocity is how fast an object changes position. V_i = initial velocity; V_f is final velocity.

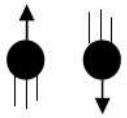
V is – if moving to the left



V is + if moving to the right

When an object turns around v = 0 m/s.

V is + when an object moves up.

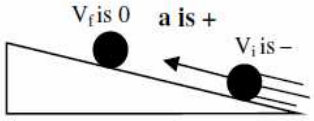


V is – when an object moves down.

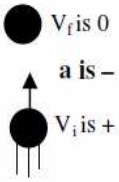
Acceleration (a) in m/s²

Acceleration is how fast an object changes velocity. The kinematic equations work only with constant acceleration. Acceleration can be positive, negative, or zero.

A positive acceleration occurs when an object speeds up in the positive direction or slows down in the negative direction.



A negative acceleration occurs when an object speeds up in the negative direction or slows down in the positive direction.



Time (t) in sec

Time is always elapsed time, not a point in time. Also, time in any other units other than seconds must be converted first.

Kinematic Equations

With these five equations you are able to calculate for any unknown in linear motion.

$$\Delta x = \frac{1}{2}(v_i + v_f)t$$ ← "a" is not used

$$a = \frac{v_f - v_i}{t}$$ ← "Δx" is not used

$$\Delta x = (v_i t) + \left(\frac{1}{2}a(t)^2\right)$$ ← "v_f" is not used

$$\Delta x = (v_f t) - \left(\frac{1}{2}a(t)^2\right)$$ ← "v_i" is not used

$$v_f^{\,2} = v_i^{\,2} + (2a\Delta x)$$ ← "t" is not used

Choosing an Equation

Just as with any other word problem, first write a variable list from the given information, including your unknown. Then choose an equation which includes these variables.

Big Trick: Figure out which variable is not used in your variable list, then chose the equation that is also not using this variable. Remember that your unknown is still in your list, you just don't know its value yet. If your unknown is not in the equation, you can't solve for it.

Variables:
Δx = 50 m
t = 10 sec
a = 2 m/s²
Vf = _____ ← Vf **is** on this list: it is the unknown.

Vi is not used in our list.

So choose this equation because it does not use "Vi" and has all of your variables.

$$\Delta x = (v_f t) - \left(\frac{1}{2}a(t)^2\right)$$

Example 1: An object moves 12 m to the left in 4 seconds. If its initial velocity was 5 m/s to the right, what is the acceleration of the object?

Variables:
Δx = –12 m (*moves left*)
t = 4 sec
Vi = 5 m/s (*right is +*)
a = _____
Vf is not in this list

"Vf" is not used → $\Delta x = (v_i t) + \left(\frac{1}{2}a(t)^2\right)$

$$-12 = 5(4) + \left(\frac{1}{2}a(4)^2\right)$$

$$-12 = 20 + \left(\frac{1}{2}a(16)\right)$$

$$-12 = 20 + (8a)$$

$$-32 = 8a$$

$$a = -4\,\text{m/s}^2$$

Example 2: An object at rest ends up moving 20 m/s to the right after traveling 80 meters to the right. How much time did this take?

Variables:
Vi = 0 m/s (*at rest*)
Vf = 20 m/s
Δx = 80 m
t = _____
"a" is not in this list.

"a" is not used → $\Delta x = \frac{1}{2}(v_i + v_f)t$

$$80 = \frac{1}{2}(0 + 20)t$$

$$80 = \frac{1}{2}(20)t$$

$$80 = 10t$$

$$t = 8\,\text{sec}$$

1. Δx, Δy, t, v_i, v_f, or a?

___ 2 sec	____ How far...	____ How long did it take?
___ 3 m/s	____ 4 m/s^2	
___ 6 m right	____ How fast...	____ How high...

2. *A person swims to the other end of a 20 m long pool and back.* What is their displacement?

3. *A rock falls 15 m.*
Is this vertical or horizontal motion?
What is the displacement of the rock?

4. *A car moving 12 m/s stops in 3 seconds.*
V_f =

5. *You throw a rock into the air and catch it as it returns.*
What is the displacement of the rock?

6. *Choose the correct kinematic equation for the following:*

Variables:
a = 2 m/s^2
V_i = 6 m/s
V_f = −6 m/s
Δx = ____

What's missing from the list:

So use this equation:

Variables:
a = 4 m/s^2
t = 10 s
V_f = −2 m/s
Δx = ____

What's missing from the list:

So use this equation:

Variables:
a = −3m/s^2
V_i = 6 m/s
V_f = −12 m/s
t = ____

What's missing from the list:

So use this equation:

7. *In 10 seconds a car accelerates 4m/s^2 to 60 m/s. How fast was the car going before it accelerated?*

Variables: Equation and Solve:

8. *A object moving 2 m/s experiences an acceleration of 3m/s^2 for 8 seconds. How far did it move in that time?*

Variables: Equation and Solve:

9. *An object at rest starts accelerating. If it travels 40 meters to end up going 20 m/s, what was its acceleration?*

Variables: Equation and Solve:

10. *A model rocket climbs 200 m in 4 seconds. If was moving 10 m/s to begin with, what is its final velocity?*

Variables: Equation and Solve:

11. *A car stops in 120 m. If it has an acceleration of −5m/s^2, how long did it take to stop?*

12. *An object drops 20 m from a cliff. If it started at rest and is going 20 m/s just before it hits the ground, what is its acceleration?*