Relative Velocity and Displacement through Area

Katie comes back to Barriere after her long vacation. She sees Abby 20m away. She runs to her at 5m/s. Abby sees her and also runs towards Katie. She runs at 3m/s. When do the hugs begin?

$d = vt$

Distance vs Time

Are the velocities in the same direction? Is this the same situation as Jesse vs Godzilla?

$d = vt$

$d = -5t$

$d_f - d_i = vt$

$d_f - 20 = -5t$

$d_f = -5t + 20$

$d_f - d_i = vt$

$d_f = 3t$

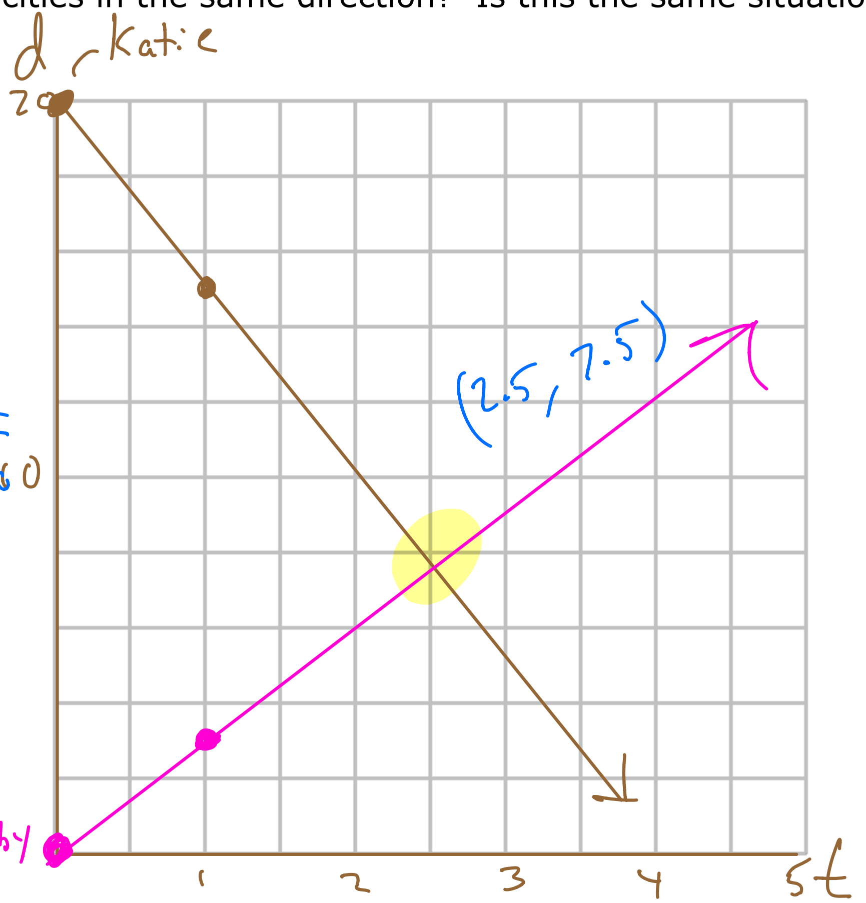
$-5t + 20 = 3t$

$-5t - 3t = -20$

$-8t = -20$

$t = \frac{20}{8}$

$= 2.5\ s$



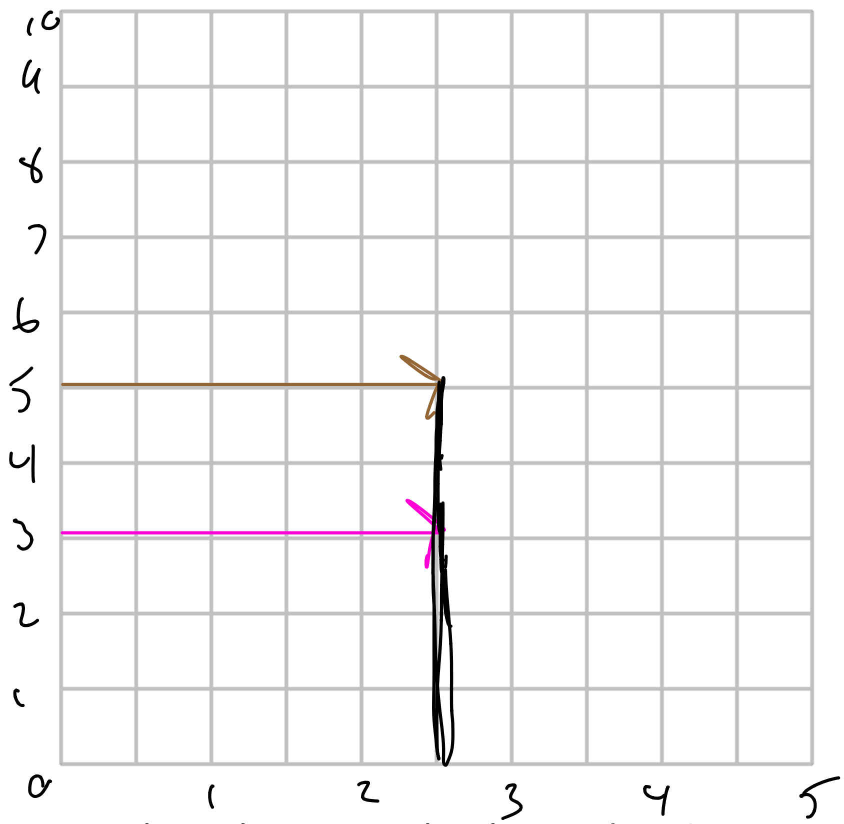
Where do the two lines meet? What time? What distance? Did they both travel the same distance?

$d_f = 3t$

$d_f = 3(2.5)$

$d_f = 7.5\ m.$

Velocity vs Time



What do we notice about the area under the two lines?

	Slope is:	Area Under is:
Displacement	Velocity	
Velocity	Acceleration	Displacement
Acceleration		Velocity

Law of Falling Bodies:

In the absence of air resistance, any two bodies that are dropped from rest at the same moment will reach the ground at the same time regardless of their mass.

Book vs ball of paper

Book vs flat paper

Book vs flat paper (paper on top)

The acceleration of all objects is the same in the absence of air resistance. As long as an object is in freefall - regardless of if the object is travelling up, down, or anywhere in between.

On Earth, that acceleration is equal to $9.81\frac{m}{s^2}$downward or -9.81$\frac{m}{s^2}$.

This is true anywhere on Earth (as Earth is roughly a sphere). If the Earth was flat is would be possible to be very close to the gravitational center, or very far from it. In this situation, gravity would vary greatly depending on your position on the disk. Someone tell B.O.B.

Acceleration due to gravity in other places in our solar system in $\frac{m}{s^2}$	
Sun	275
Jupiter	25.0
Terra (Earth)	9.8
Venus	8.9
Moon	1.6

Weightless Water

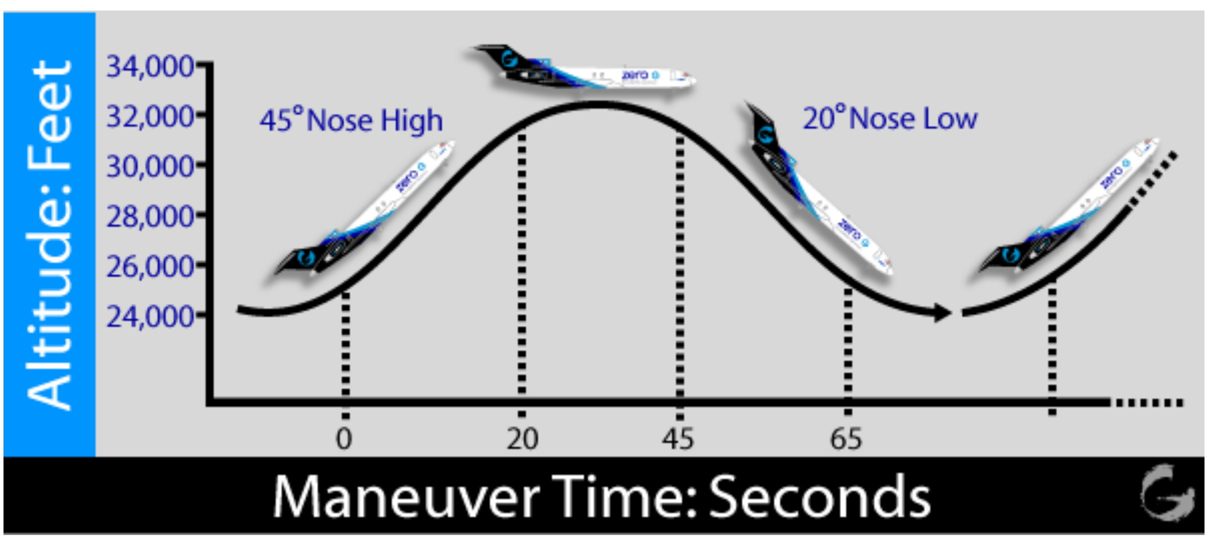
What do you notice?

What happens when you jump?

What happens when you throw the cup?

This feeling of weightlessness (the sensation that you are not experiencing the downward pull of gravity) is also experienced by riders on free-fall rides. On the way to the top, the riders are pressed against their seats, which provides a sense of weight. But as they free fall, they fall at the same rate as their surroundings - in this case, their seats. Without the force of their surroundings pressing on them, the riders feel like they are weightless. But, in fact, they do have weight and are being acted upon by the force of gravity.

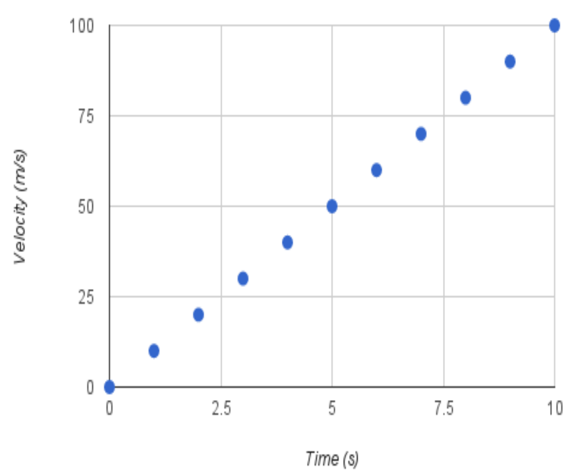
Vomit comit:



Is Stephen Hawking floating, falling, or flying?

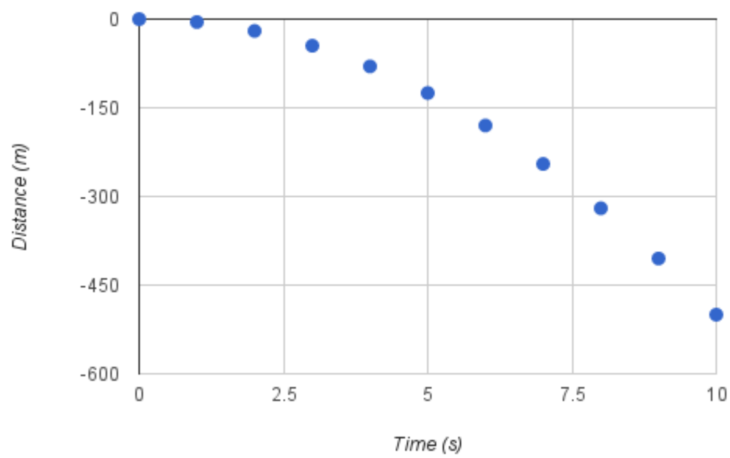
Assume that $g = 10\frac{m}{s^2}$. This means that your velocity will increase by 10 m/s every second. If you drop something from rest off of a cliff - after one second it will have a velocity of 10 m/s. After two seconds it will have a velocity of 20 m/s. In a table it looks like this:

Time	Velocity
0	0
1	10
2	20
3	30
4	40
5	50
6	60
7	70
8	80
9	90
10	100



The slope is 10 m/s per second. $\frac{rise}{run}$.

Same object. Same acceleration. Same cliff. Let's look at position:



What are the units of the slope?
What shape is this?

But, Mr. Connor: All this assumes no air!

That's true. All objects fall at $9.8\frac{m}{s^2}$ on Earth without air resistance.

We can make this assumption if three things are true:

1) Heavy compared to it's size. When something falls through air, the air molecules hit it on the way down. Observe a crumpled piece of paper vs a flat piece. A piece of plywood vs a log.
2) It falls for a relatively short time. In other words, we cannot approach terminal velocity. This is when you fall at maximum speed. Your velocity is fast enough that you hit enough air molecules on your descent that they balance the downward acceleration. At this point your velocity is constant. ie: no acceleration.
3) It is moving relatively slowly. If you drop something it is in free fall. If you launch it out of a rail gun - it is not.

Type I Problems: Falling

A bowling ball is dropped off of a 200m cliff.

How far does it fall in 4 seconds?
How fast will it be travelling in that time?

Method 1: Think it through

The acceleration of the ball is 9.8$\frac{m}{s^2}$. It travels for 4 seconds. Therefore the velocity will increase by 9.8$\frac{m}{s^2}$every second. 4(9.8)=39.2m/s.

The acceleration is constant. Therefore we can use the average velocity in distance calculations. $\frac{v_f - v_0}{2} = \frac{39.2-0}{2} = 19.6 m/s$. I can use 19.6m/s as my velocity and multiply that by 4 to get my distance. 19.6(4)=78.4m.

Method 2: Create a Table

Time (s)	Velocity (m/s)	V_{avg} (m/s)	Distance (m)
0	0	0	0
1	9.8	$\frac{9.8+0}{2} = 4.9$	vt=4.9
2	19.6	9.8	19.6
3	29.4	14.7	44.1
4	39.2	19.6	78.4

v_f=39.2. d_f=78.4

Method 3: Algebra

$\Delta v = at$
$v_f - v_0 = -gt$

$v_f - 0 = -9.81(4)$
$v_f = -9.81(4)$
$= -39.2\ m/s$

$$\Delta d = v_0 t + \frac{at^2}{2}$$

$d = 0(4) + \frac{-9.81(4)^2}{2}$
$= 78.4\ m$

Your turn: On Jupiter. You choose the method.

You guys found the school to be roughly 3m high. We drop a watermelon from the roof. How long until it hits the ground?

$$\Delta v = at \,||\, \Delta d = v_0 t + \frac{at^2}{2}$$

What if we dropped a bowling ball instead?