Newton, Newton, and Newton

Newton's First Law:

Things tend to keep doing what they were doing…

Have you ever held a very full cup of coffee while sitting in a car? How careful do you have to be? Why?

[CWD-Video]

What happens to you when the car brakes quickly?
What happens to you when the car accelerates quickly?

Other examples?

Misconceptions:

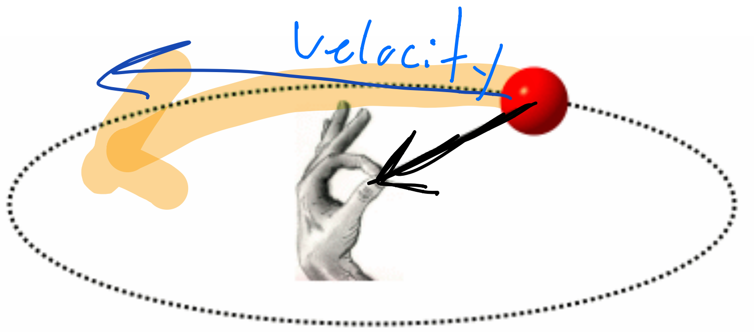
Prior to Newton people thought that objects naturally wanted to come to rest. They thought that having a velocity of zero was a preferred energy state, and given time all objects would come to have a zero velocity… No one here thinks that though, right?

Newton's first law is exactly the opposite of this. A force is needed to change an object's speed. If we slide a book across the desk, we can see it come to a stop… why?

Inertia: Tendency of an object to resist changes in its velocity. Related directly to an object's mass.

If we have two bricks. One made of clay, and one of styrofoam. They look identical. You cannot pick them up. How can you tell which is which?

1)Tricky Example:



When I let go, which direction does the ball go?

2)

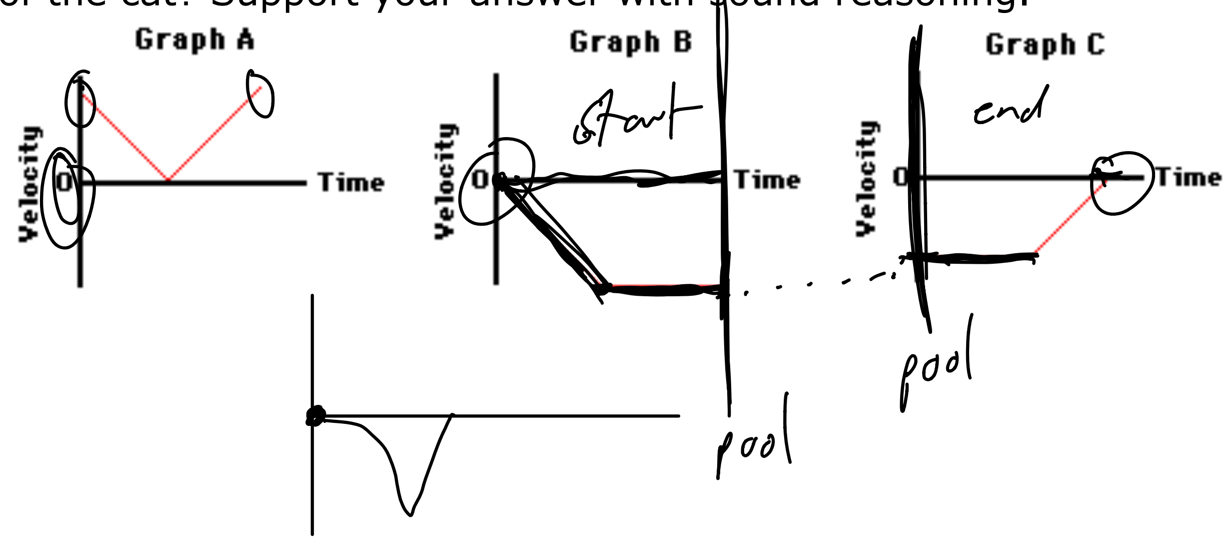
A 4.0-kg object is moving across a friction-free surface with a constant velocity of 2 m/s. Which one of the following horizontal forces is necessary to maintain this state of motion?

0N	.5N	2N	8N	Depends on speed

3)

Jesse drops an approximately 5.0 kg fat cat (weight = 50.0 N) off the roof of his house into the swimming pool below. Upon encountering the pool, the cat encounters a 50.0 N upward resistance force (assumed to be constant).

Which one of the velocity-time graphs best describes the motion of the cat? Support your answer with sound reasoning.



Jesse had some friends over at his house to watch him throw the cat into the pool. Of course Jesse only has friends who enjoy physics, so they spoke about the incident. Here is what they said…

False

A. Once the cat hits the water, the forces are balanced and the cat will stop.

False

B. Upon hitting the water, the cat will accelerate upwards because the water applies an upward force.

False

C. Upon hitting the water, the cat will bounce upwards due to the upwards force.

Newton's 2nd Law:

The first law is all about balanced forces. $F_{net}=0$.
However we see objects begin to move. Come to a stop. Change direction. All the time. This requires an unbalanced force.
$F_{net} \neq 0$

Complete this chart:

F_{net} (N)	Mass (kg)	Acceleration (m/s^2)
10	2	5
20	2	10
20	4	5
10	2	5
10	1	10

What happens to acceleration when you double the net force?

What happens to acceleration when you half the net force?

$\frac{2F}{m} = a$ $\frac{F}{2m} = a$

$a \propto F$ directly proportional

$F = ma$

$\frac{F}{m} = a$

What happens to acceleration when you double the mass?

What happens to acceleration when you half the mass?

$a \propto \frac{1}{m}$ inversely proportional

$\frac{F}{2m} = a$

$\frac{F}{m/2} = a(2)$

Example:

An applied force of 20N is used to accelerate a 1kg object to the right across a frictional surface. The object encounters 10 N of friction. determine the normal force, the net force, the coefficient of friction (μ) between the object and the surface, the mass, and the acceleration of the object. (Neglect air resistance.)

$F_f = \mu F_n$

$F = ma$

$F_{net} = 20 - 10$

$= 10N$

$F_n = ?$ 9.81N

$F_{net} = ?$ 10N

$\mu = ?$ 1.02

$m = 1$

$a = ?$ 10 m/s²

$\frac{F_f}{F_n} = \mu$

$\frac{10}{9.81} = \mu$

$1.02 = \mu$

$F_n = ma$

$F_n = 1(9.81)$

$F_n = 9.81\ N$

$10 = 1a$

$\frac{10}{1} = a$

co = a

Example:

A 5-kg object is sliding to the right at 3.1 m/s and encountering a friction force which slows it down in 2.5s. The coefficient of friction (μ) between the object and the surface is 0.1. Determine the force of gravity, the normal force, the force of friction, the net force, and the acceleration. (Neglect air resistance.)

Hint: $a = 8.82\ m/s^2$

$F_n = ma$
$= 5(9.81)$
$F_n = 49$

$F_f = \mu F_n$
$= .1(49)$
$= 4.9$

$F_{net} = 49 - 4.9$
$= 44.1$

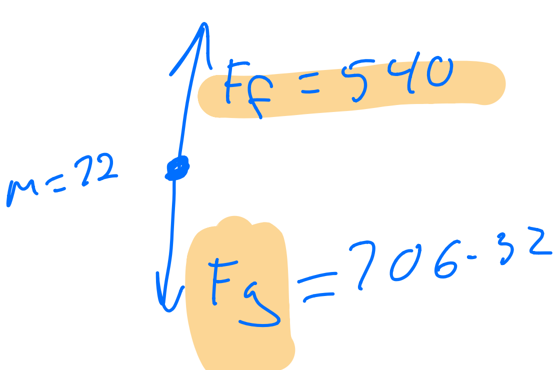
$F = ma$
$44.1 = 5a$
$\frac{44.1}{5} = a$

Example:

A 72-kg skydiver is falling from 3km. At an instant during the fall, the skydiver encounters an air resistance force of 540 Newtons. Determine the acceleration of the skydiver at this instant.

$a = 2.3\ m/s^2$

$F_g = ma$
$F_g = 72(9.81)$
$F_g = 706.32$



$F_{net} = 706.32 - 540$
$= 166$

$F = ma$
$166 = 72a$

$$\frac{166}{72} = a$$