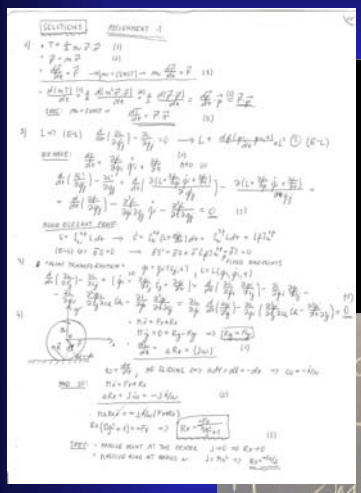
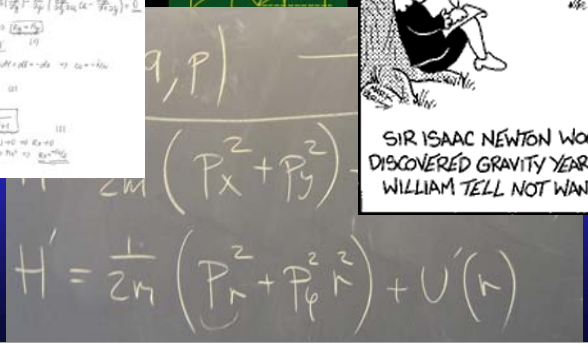
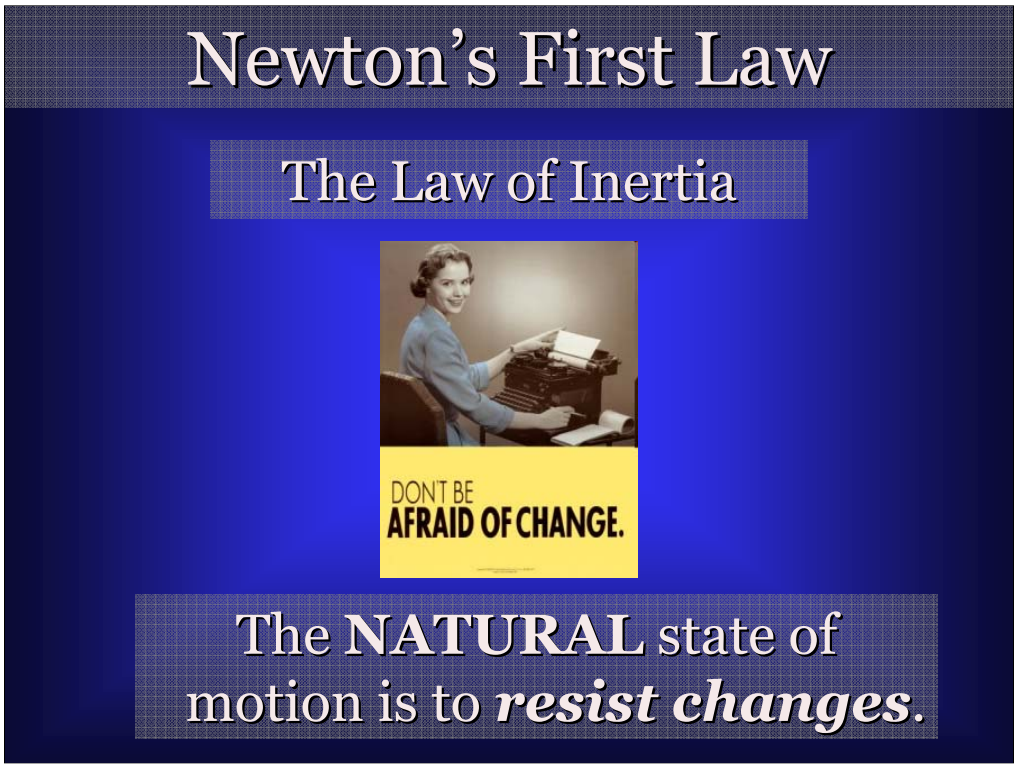
Classical Mechanics







The NATURAL state of motion of an object is to keep doing what it's doing.

Galileo already said this.

Aristotle divided the universe into "The Heavens" and "The Earth"

The "Heavens" were eternal and unchanging. The natural state of the heavens was perfect motion.

The Earth was temporary and ever changing.

The natural state of motion of Earth bound objects was rest.

Newton (and Galileo) said that the natural state of motion is to not change.

Newton's Second Law

A *change in motion* is caused by a **FORCE**

Galileo didn't say this.

To get an object to change, a force must be applied.

When we push the gas pedal in the car, the engine generates a force causing the car to move.

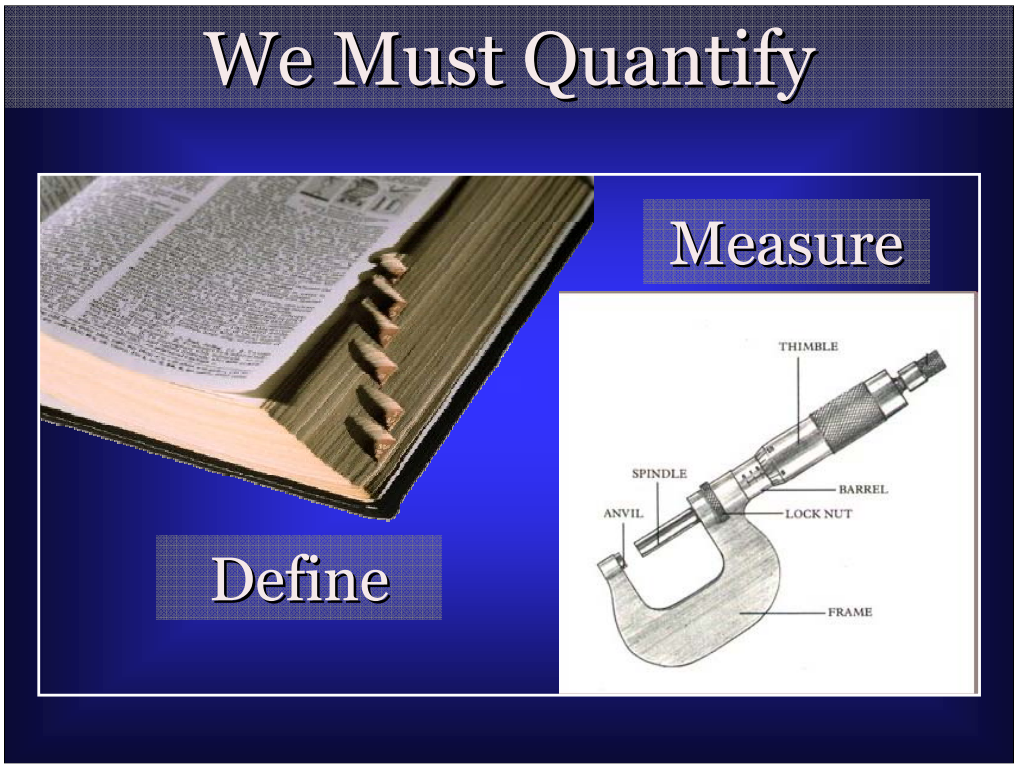
Why does the car stop if I stop pushing with the engine?

Newton's Third Law

If you **PUSH** on something, it ***pushes back***

Forces come in pairs.

If you apply a force to something, it responds by pushing back.
As I push against a baseball to throw it, I can FEEL it pushing back.



We have described Newton's three laws in a general QUALITATIVE way.

But, as we learned from our Time Gnome discussion, we need to be much more precise.

We have to carefully DEFINE our terms so that we can make careful MEASUREMENTS.

We use mathematics to build models so we need to figure out how to QUANTIFY the world.

What EXACTLY does the first law mean?

What do we mean by "Motion"

What do we mean by "Rest"

ABCD

How many numbers do we need to describe our POSTION in the Universe?

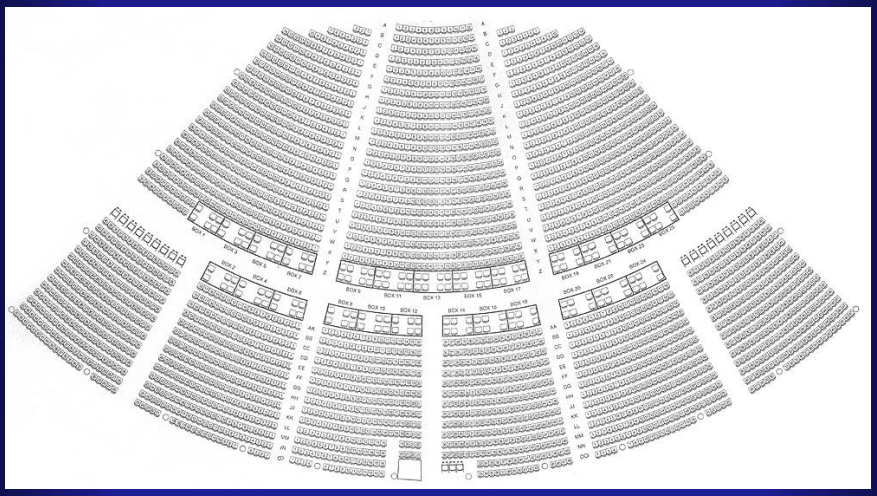
A. One

B. Two

C. Three

D. More than three

Position



Coordinates describe position

How would you describe your position in the class room?

We need two numbers or “Coordinates”
The row and column of the seat…

We also have to define our point of reference

Our Coordinates give our position RELATIVE to what?

Where precisely is the ‘orgin’ of the coordinate system?

The ORGIN is where we start counting our units of measure.

What if there were several balconies also? Then we would need a THIRD number.

Think about baseball tickets.

Section, row, seat AND… TIME.

We also need to know WHEN to be there.

An alternate description is DISTANCE and DIRECTION.

Velocity

Velocity has something to do with changes in SPATIAL position.

The other element is time.

Velocity is the RATE of change in position.

It takes into account direction.

VELOCITY is the thing that remains constant barring outside influence.

Acceleration

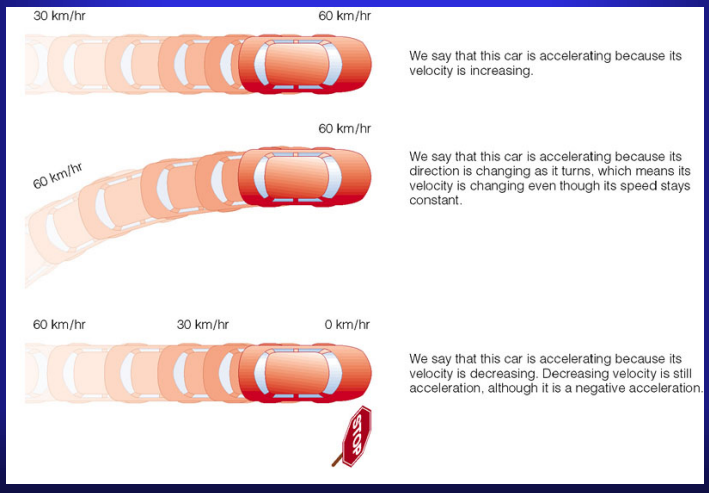
Define velocity… Note that it is a combination of Speed AND Direction.

Define force as causing a change in velocity

A change in direction… IS a change in velocity

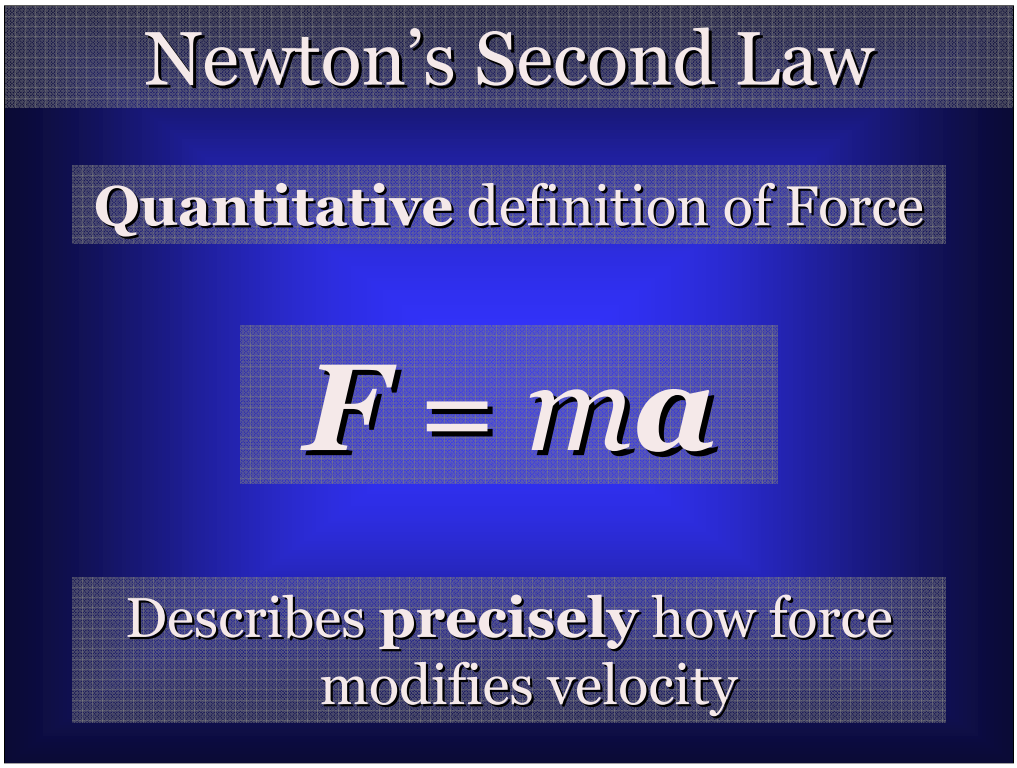
Note net force… sum of all forces…

Acceleration



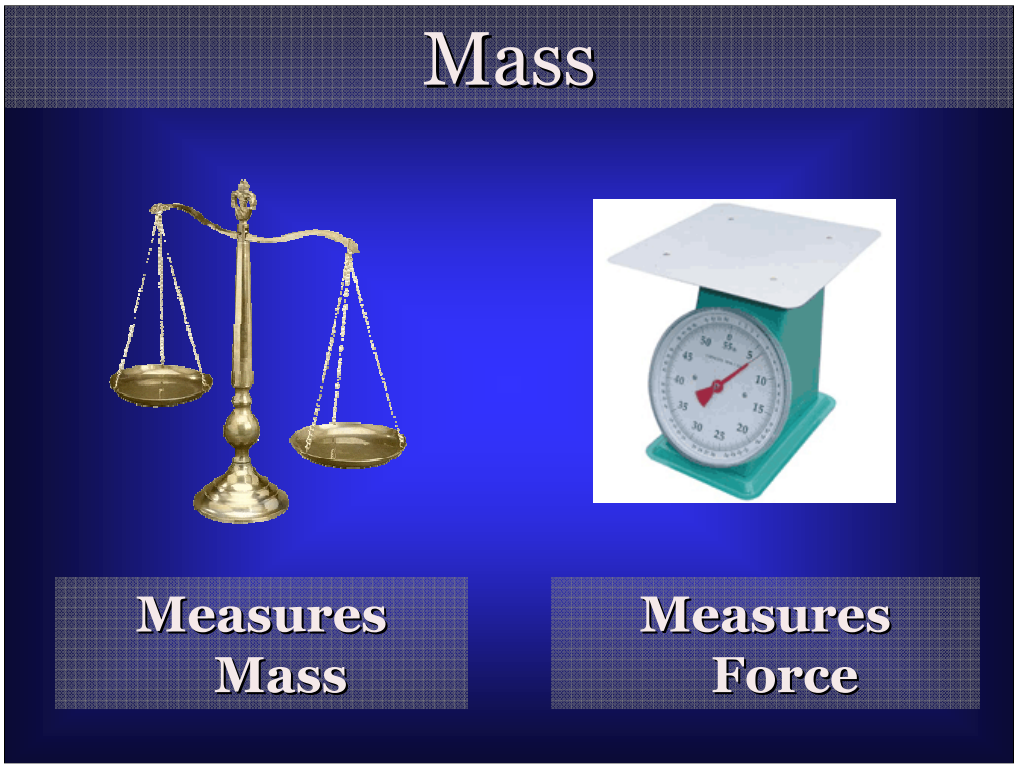
So… forces cause changes in velocity… or accelerations.

The acceleration is proportional to the force… and inversely proportional to the mass.



We can actually make mathematical predictions with this equation…

This equation DEFINES what we mean by inertial mass.



Balance scale:

Balance test object against a REFERENCE mass

Independent of gravitational force.

You'll get the same answer on Mars as on Earth

Spring scale.

Measurement is dependent on gravitational force.

Measures how far a spring is stretched or compressed, which is a measure of FORCE.

You'll get DIFFERENT answers on Earth versus Mars

Newton's Third Law

Forces come in pairs

Give a few examples of force pairs…

Standing on the ground

Pushing on a wall

Bug hitting a windshield

Throwing a baseball

Universal Law of Gravitation

$$F = G\frac{M_1 M_2}{r^2}$$

Objects with **mass** exert an attractive force on one another.

Gravitation

The gravitational FORCE on  near the Earth's surface is

A. less than

B. greater than

C. the same as

the gravitational force on  near the Earth's surface.

Gravitational force is DIRECTLY PROPORTIONAL to the mass of the objects in question.

more mass = more force.

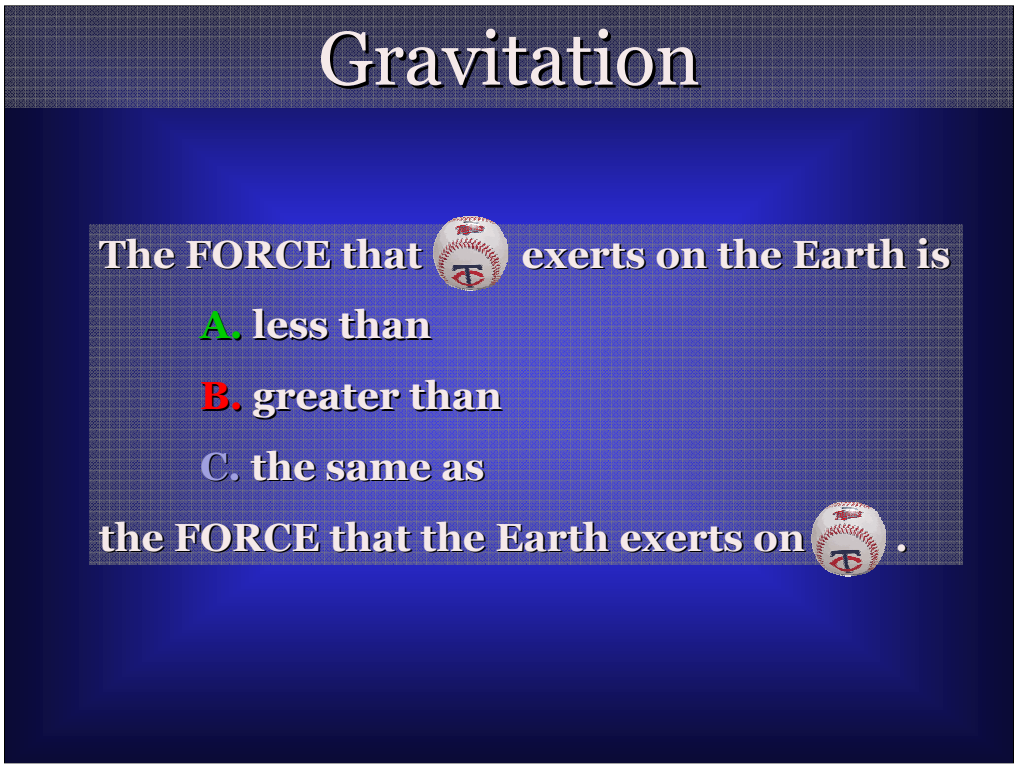
If the mass doubles, the gravitational force doubles.

Remember! We are talking about the force to due BOTH masses:

The Earth and the ball.

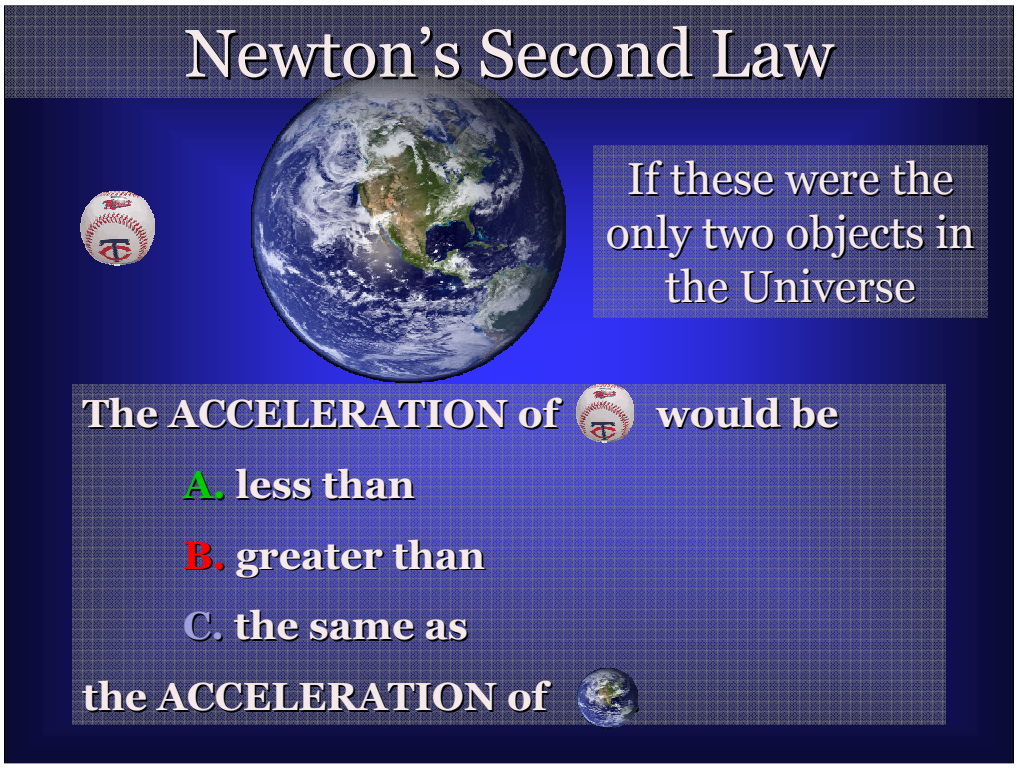
If I double the mass of the Earth: the gravitational force doubles

If I double the mass of the ball: the gravitational force doubles



Forces come in PAIRS.

For every force, there is an EQUAL AND OPPOSITE force.
The ball is pulling on the Earth just as hard as the Earth is pulling on the ball.



MASS and INERTIA are the same thing.

It's a measure of an object's RESISTANCE to change.

It's REALLY hard to convince the Earth to change. (what do I mean by change here?)

The baseball isn't as hard to convince.

The FORCE on the two of them is the SAME so …

Why?