Physics 20 Unit II - Forces

Introduction to Forces

Forces = Dynamics

Up until now, we have only been concerned with how things move:

- how fast
- how far
- how fast

The study of how things move is called kinematics.

Today, we start to consider why things move.

The study of why objects move is called dynamics.

Forces

A force is sometimes described as a push or a pull.

What are some forces you can think of?

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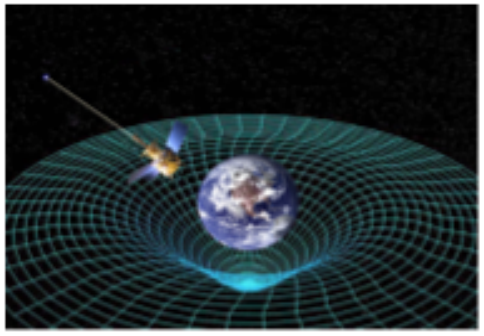
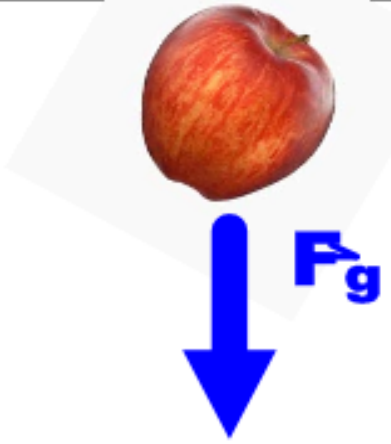


Gravity



- An attractive force which governs the shape of the universe.

- Exerted by all bodies on all bodies in the universe.

- Depends on mass and separation between bodies.

- Can act over very long distances.

- Acts through gravity fields.

Newton's Laws of Motion

In 1687, at the age of 23, Sir Isaac Newton published perhaps the most important book in math or physics: the Principia Mathematica. The book contained (among other things) three laws that governed all motion in the universe.

And even though these ideas are over 300 years old, they still hold up as a good basis for understanding dynamics.


AXIOMATA
SIVE
LEGES MOTUS

Philosophiae Naturalis Principia Mathematica (1687)

Newton's First Law:

The Law of Inertia

Newton said...

"An object continues in a state of rest or in a state of motion at a constant speed along a straight path, unless acted on by a net force."

Okay.

Net Force: the overall force, the sum of all forces acting on a body from all directions.

Gravity Switch

Now that you've heard the first law, consider this with a partner:

Suppose gravity could be turned off and on by a switch. What would happen to the following in the classroom when the switch was switched off;

- the desks
- A spitball flying through the air
- you!

And: what would happen when the gravity was switched back on?

Space Place

Suppose you are standing outside the ISS in outer space far from the effects of gravity. You apply a force to a baseball by hitting it with a bat.

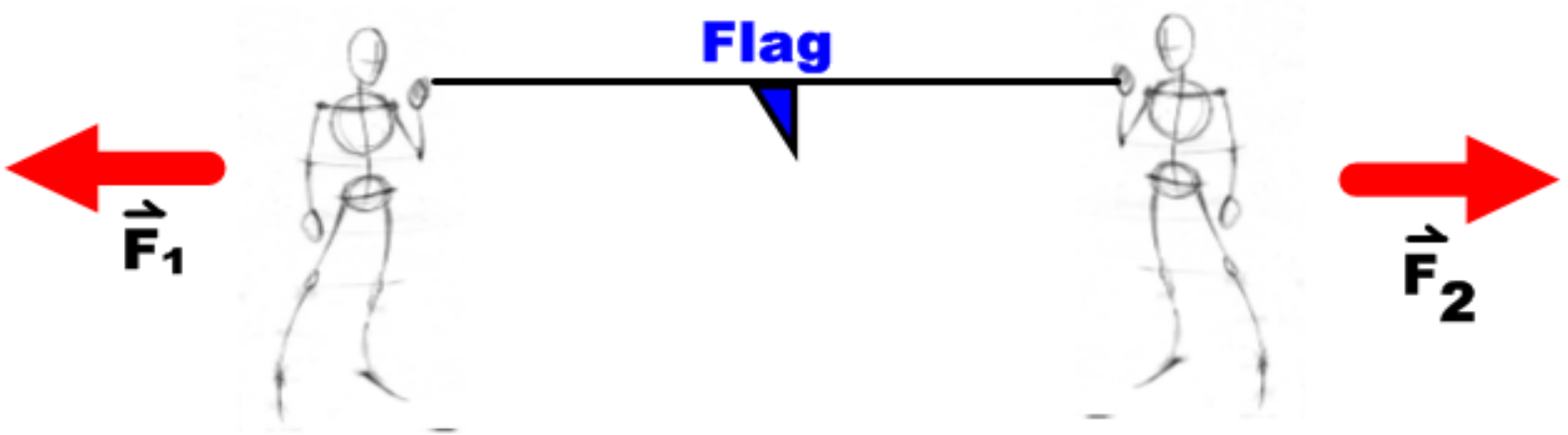
- What direction will the ball travel in?
- Will the ball stop after no more forces are acting on it?
- Is it moving with a constant velocity, or constantly accelerating?

if $F_{NET} = 0$,
$v = \text{constant}$

These experiments all deal with the first law. Let's look at some more concrete examples of the first law.

Here's an example where an object stays at rest even though there are forces acting on it.

ex) A tug-of-war (a force-diagram)

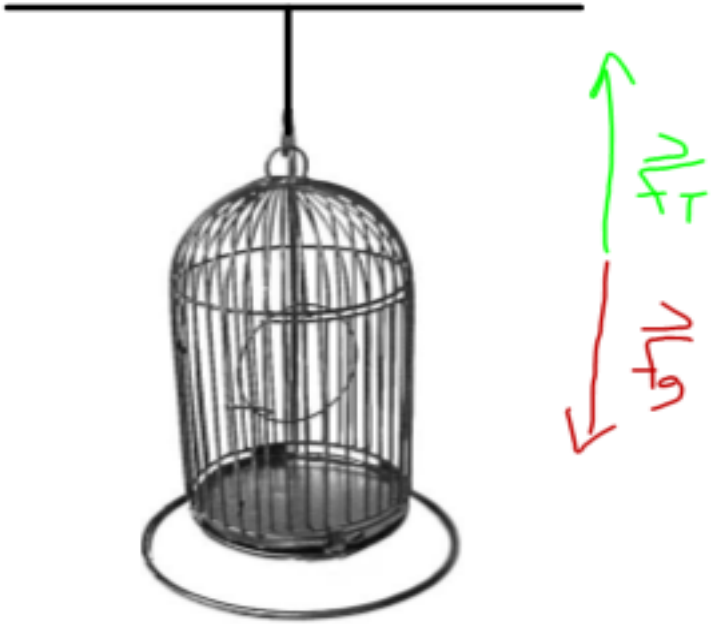


If $\vec{F}_1 = \vec{F}_2$ (in magnitude), the flags stay at rest.

If $\vec{F}_1 > \vec{F}_2$ (in magnitude), the flag moves _____.

If $\vec{F}_1 < \vec{F}_2$ (in magnitude), the flag moves _____.

Here's another example of what Newton considered an object at rest in first law:



What forces are acting on this birdcage?

Will it fall?

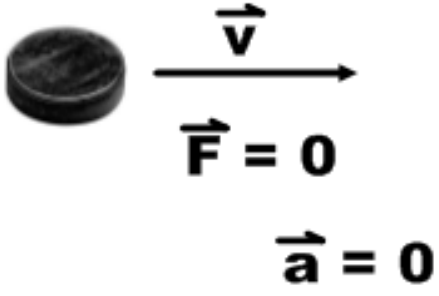
As long as $F_g = F_T$ (in magnitude), resulting in a net force, the cage will stay at rest.

Now, let's look at some examples of objects continuing with a straight path and constant speed.

ex) Hockey Slap Shot

①

②



At point 1, the stick applies a force to the puck. The puck is accelerated in the direction of the force with an acceleration and a velocity in the direction of the acceleration.

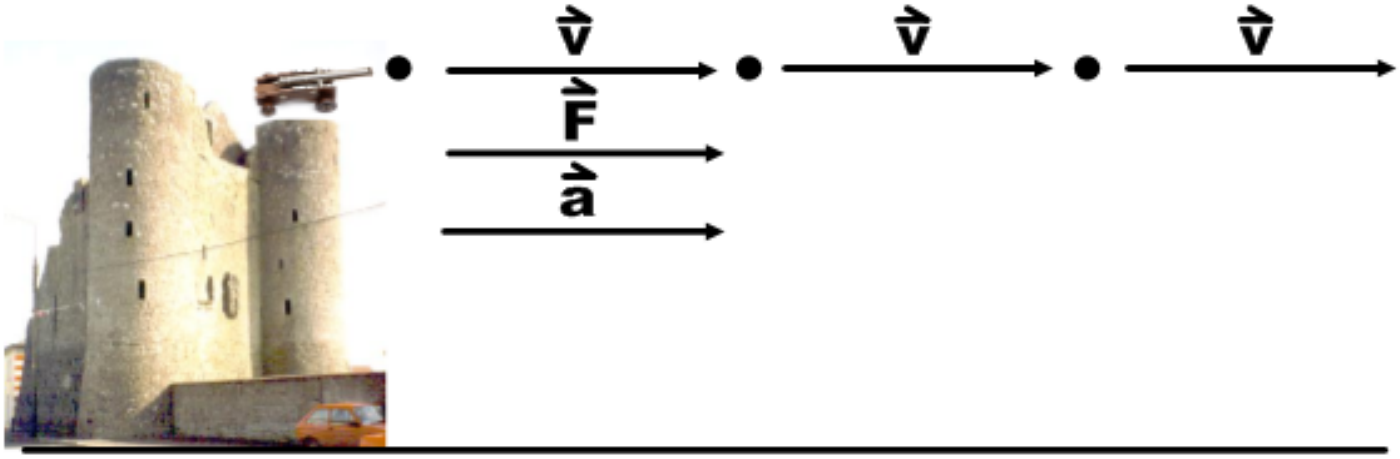
Some amount of time later, 2, the force is gone, but the puck keeps on moving with a constant velocity in a straight line.

*No force is needed to keep the puck going!

③

The puck will only stop when a force is applied to it (from another object, friction, air resistance, etc.)

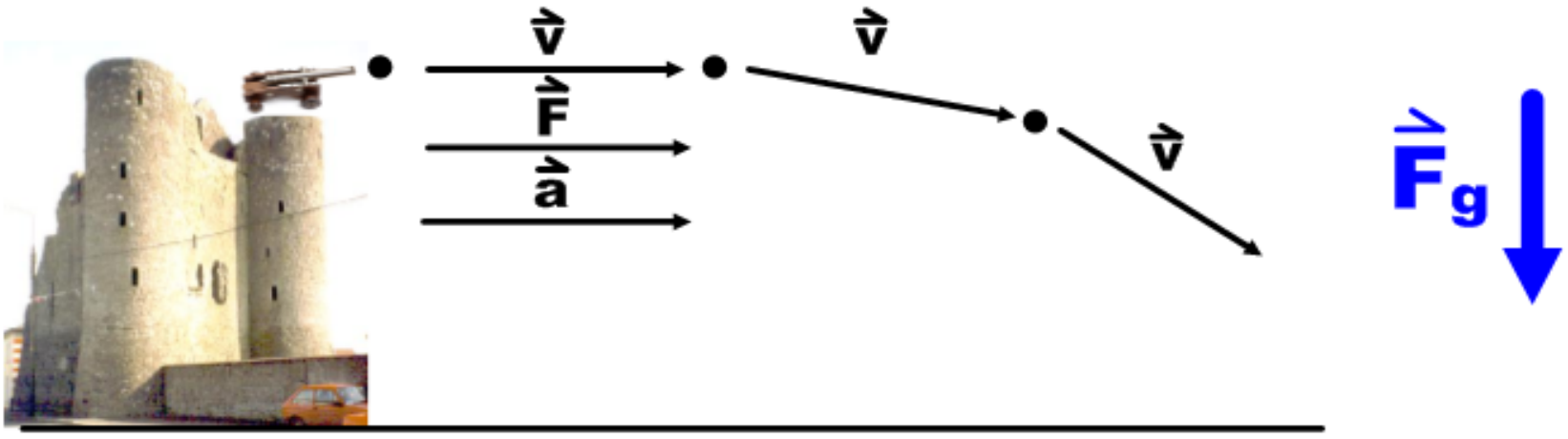
ex) Cannon : Ignoring Gravity



A cannon is fired, providing a ball with a force and an acceleration.

-Ignoring gravity, the ball will travel with a constant velocity in a straight line.

ex) Cannon : Observing Gravity



Taking gravity into account, the ball will begin to vary from its course. The ball is accelerated in the y-direction because of the course of gravity.

However, in the x-direction, the velocity and movement does not change because no new forces are acting on the ball.

Inertia

- Kind of hard to pin down.

Inertia is a scientific idea, a property of matter, the natural tendency of an object at rest to stay at rest and an object moving to stay moving.

Inertia can not be measured, but can be thought of in a qualitative way:

Partnered Activity: Which has more inertia?

A bat or a bee?

A shrimp or a blimp?

1 kg or 2 kg?

Inertia is related to mass. More massive objects have more inertia.

Mass

Symbol: m

Unit: kg

Mass is difficult to define at this stage, but it can be roughly described as the amount of space an object occupies.

CAUTION: it is very important that you don't confuse mass and weight.

Recall the old Riddle:

Which weighs more: a tonne of feathers or a tonne of bricks?

or...

What is weight?

Weight

Symbol: F_g

Unit: kgm/s^2 or N

Weight is the amount of force due to gravity acting on an object, or the amount of pull.

Weight is a force! And it can vary from planet to planet. Mass is an intrinsic property of matter! It remains the same everywhere in the universe!