Yoda!

Science 20 Unit B - Physics

Forces and Newton's Laws

POS Checklist:

- ☐ explain how an unbalanced force causes change in motion and apply Newton's first law of motion to explain an object's state of rest or uniform motion.
- ☐ apply Newton's second law of motion and use it to relate force, mass and motion.
- ☐ apply Newton's third law of motion to explain the interaction between two objects.

Forces

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

What are some forces you can think of?

- gravity!
- magnetism!
- friction
-
-
-

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 <u>Principia Mathematica. The book</u> 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.

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 an overall force."

Partnered Gedanken:

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?

Partnered Gedanken:

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?**

Another way of thinking of the first law is using inertia.

Inertia - the tendency of an object at rest to want to stay at rest, and an object in motion to want to stay in motion.

inertia gedankin:

Do you notice how large objects are difficult to get moving at first...

...but once they get going, they're hard to stop?

That's inertia.

Newton's Second Law

Any overall force produces an acceleration.

Simply put:

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

where:

$\vec{F}$ = force (kgm/s^2 or N [a newton])
$\vec{a}$ = acceleration (m/s^2)
m = kg

Applying the Second Law:

ex) LD has a mass of 100 kg. What force is needed to accelerate LD to 1.5 m/s²?

$\vec{F} = m\vec{a}$
$= (100kg)(1.5m/s^2)$
$= 150N$
$= 1.5\times10^2N$

ex) A spring-scale can pull with a force of 2.0 N. What is the maximum acceleration such a scale could give to a 3.5 kg object?

$\vec{F} = m\vec{a}$
$2.0N = (3.5kg)\vec{a}$
$\vec{a} = 0.57m/s^2$

ex) LD's mass is 88.18 kg. What is his weight?

You find weight by using $-9.81 m/s^2$ (the acceleration due to gravity) as your $\vec{a}$.

Hint: mass is measured in kg, but weight is measured in newtons.

$$\vec{F} = m\vec{a}$$
$$= (88.18 kg)(-9.81 m/s^2)$$
$$= -865.0 N$$

Newton's Third Law

"For every force, there is an equal and opposite force."

Forces do not exist all by themselves, they occur in pairs. We can never have one force acting all by itself*.

This force is equal in magnitude and opposite in direction.

*Although we only focus on one force for simplicity.

Gedanken:

Repair Scare

You are in outer space fixing the International Space Station. Your tether suddenly breaks and you find yourself at rest in space.

You don't have fancy rockets or anything to get back to the station. You do, however, have a wrench.

How can you get back to the station?

ex) Henrik Sedin has a puny mass of 75 kg. Zdeno Chara has a manly mass of 125 kg. If Chara pushes Sedin with a force of 15 N, what is the acceleration of both players?

Secret Rock'em Sock'em Thing

$\vec{F} = m\vec{a}$ ← for Sedin

$15 N = (75 kg)\vec{a}$

$\vec{a} = 0.20 m/s^2$

$\vec{F} = m\vec{a}$ ← for Chara

$15 N = (125 kg)\vec{a}$

$\vec{a} = 0.12 m/s^2$

Practice Problems:

ex) A 22 kg object accelerates uniformly from rest to a velocity of 2.5 m/s west in 8.7 s. What is the net force acting on the ~~car~~ object during this acceleration?

Step 1 → Find $\vec{a}$

$$\vec{a} = \frac{\Delta \vec{v}}{t} = \frac{2.5 m/s}{8.7 s} = 0.2874 m/s^2$$

Step 2 → Find Force

$$\vec{F} = m\vec{a} = (22 kg)(0.2874 m/s^2)$$
$$= 6.3 N$$

~~ex) A net force of 6.6 N [E] acts on a 9.0 kg object. If this object accelerates uniformly from rest to a velocity of 3.0 m/s [E]~~

~~a) How far did the object travel while accelerating?~~

~~b) What is the time of acceleration?~~

Omit

https://www.youtube.com/watch?v=BXkq6V7Ipi0