0.1 Unit 03 - Forces

0.1.1 September 20, 2021

1 **Definition** (Force)
Any interaction between any two objects.

Fundamental forces

2 **Definition**
Gravitational force - the interaction of gravitational forces. By far the weakest force.

3 **Definition**
Electromagnetic force - the fundamental force that dictates 98% of forces you experience on an everyday basis. Holds together molecules. Ex. rub a balloon on your head.

- People are mostly made up of empty space.
- Why do you feel the desk? Photon-photon interactions.

4 **Definition**
Strong Nuclear Force - since atoms are all charged positively in the nucleus and should theoretically repel each other, they still stick together because of strong nuclear force.

- Strongest force. Only works over small distances.
- Making these using $E = mc^2$ then it can easily turn into a nuclear reaction.
- To make a nuclear fusion reaction, two atoms must collide with large amounts of energy.

5 **Definition**
Weak Nuclear Force - underlies radioactivity and decay

- The effective range of the weak force is limited to subatomic distances, and is less than the diameter of a proton.

Newton's Three Forces

- An object at rest stays at rest and an object in motion stays in motion with the same speed and in the same direction unless acted upon by an unbalanced force. Aka inertia - laziness.
- $\sum F = ma$
- Newton's third law states that when two bodies interact, they apply forces to one another that are equal in magnitude and opposite in direction.

6 **Remark**
The third law acts on two different objects.

Proof (Newton's Second Law).

$$\sum F = \frac{d\vec{p}}{dt}$$

$$\int F dt = \int dp$$

$$\vec{J} = \int F dt = \Delta p$$

$$\sum F = m\frac{dv}{dt}a$$

$$\sum F = ma$$

□

7 **Example** (Newton's Third Law)
Someone pushes on the wall. The wall exerts a force on the person, whose friction keeps them still - and pushes opposite of the direction of the force.

$F_g = W = mg$

0.1.2 September 21, 2021

8 **Theorem**
$tan\theta = \mu$

Incliners, or atwood machines:

- 1.4 kg box on the left
- 1.5 kg box on the right
- Then the box on the right falls.
- Speed: relatively slow.

0.1.3 September 23, 2021

9 **Theorem** (Getting velocity from period)

$$v = \frac{2\pi r}{T}$$

10 **Theorem** (Centripital force + Acceleration derivation)

$$F_c = \frac{mv^2}{r}$$

$$v = -v_x i + v_y j$$

$$v = (-v\sin\theta)i + (v\cos\theta)j$$

Then, draw a triangle on the center of the circle.

$$\sin\theta = \frac{y}{r}$$

$$\cos\theta = \frac{x}{r}$$

$$\begin{aligned} a &= \frac{dv}{dt} \\ &= (-\frac{v}{r} - \frac{dy}{dt})i + (\frac{v}{r}\frac{dx}{dt})j \\ &= (-\frac{v}{r}v_Y)i + (\frac{v}{r}v_x)j \\ &= (\frac{-v}{r}v\cos(\theta))i + (\frac{v}{r}v\sin(\theta))j \end{aligned}$$

Setup pythagorean theorem:

$$\begin{aligned} a &= \sqrt{\left(\frac{v^2}{r}cos\theta)\right)^2 + \left(\frac{v^2}{r}\sin(\theta)\right)^2} \\ &= \frac{v^2}{r}\sqrt{cos^2\theta + \sin^2\theta} \\ &= \frac{v^2}{r} \end{aligned}$$