Lesson 3

1 Newton's Laws

- Philosphiae Naturalis
- Principia Mathematica in 1687

1.1 Newton's First Law

An object in motion moves in staight lines at constant speed unless acted upon by an external force

- **Inertia** - "Reisistance to change" in velocity
- **mass (m)** - Inertia of a physical object
  - More mass = More resisitance to change

1.2 Newton's Second Law

A force is the change in momentum (p) per unit time

force (F) – first derivative of *momentum* WRT *time*

* *WRT – With respect to*

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

$$g(x,t)$$
$$g' = \frac{dg}{dx}$$
$$\dot{g} = \frac{dg}{dt}$$

$$\vec{p} = m\vec{v}$$

$$\begin{aligned} \sum \vec{F}_{ext} &= \vec{\dot{p}} \\ &= m\overrightarrow{dotv} + \dot{m}\vec{v} \end{aligned}$$

$$\boxed{\sum \vec{F}_{ext} = m\frac{d\vec{v}}{dt}}$$

There are only a handful of forces. There are two broad categories:

Long Range	Contact
Gravity (1A)	Friction
Electromagnetic (1C)	Normal
Strong (1D)	Applied
Weak (1D)	Tension
	Orange
	Drag (1B)

** Text within parenthesis refers to physics courses where the force is covered in detail*

Force definitions

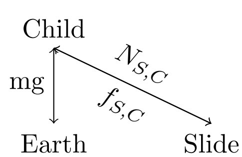
- **Normal force (N)** - Perpendicular to surface of contact, and always points away from the surface
- **friction (f)** - Parallel to contact surface
  - $f = \mu N$
  - μ – "coefficient of friction"
- **Tension** (F_T, T) - Carried along a rope or change & points away from the object
  - Tension is <u>not</u> uniform if: rope has mass, massive pulley

1.3 Newton's Third Law

Every force creates a reaction force which acts on a different object. These forces are equal in magnitude and opposite in direction.

Drawing a diagram

1. Draw a simplified diagram
2. Identify points of contact
3. List all relevant forces
4. Draw a free body diagram

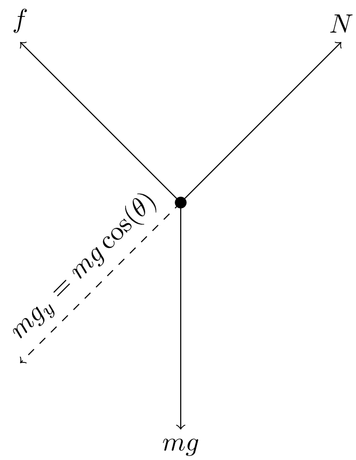


Static -

$$\frac{d\vec{v}}{dt} = 0$$

$$\sum F_{ext} = 0, \text{ if } m = 0$$

What value does μ have if m, g, & θ are known?



$$f = \mu N$$

Always start with a $\sum F$ statement

x Direction:

$$\sum F_x^{(m)} = 0$$

* Where x is direction and (m) is the object

$$mg\sin(\theta) - f = 0$$

$$f = mgsin(\theta)$$

y Direction:

$$\sum F_y^{(m)} = 0$$

$$N - mg\cos(\theta) = 0$$

$$f = \mu N$$

$$mg\sin(\theta) = \mu(mg\cos(\theta))$$

$$\mu = \frac{\sin(\theta)}{\cos(\theta)} = \tan(\theta)$$

2 Density

Density:

$$\frac{dm}{dy} = \frac{M}{L}$$

$$dm = \frac{M}{L} dy$$

$$dT = g dm$$

$$\int_0^T dT = \int_0^y \frac{Mg}{L} dy$$

$$T = \frac{Mg}{L} y$$