Dynamics - Force and Motion

"Why" things move.

1687 Newton collected existing ideas
clarified ideas
created math to put ideas on paper

\[ \text{Principia} = \text{"bible" of classical physics} \]

- New concept **FORCE** ("action")

\[ \text{"2nd Law"} \]

- acceleration is caused by force
- inertia (mass) is resistance to acceleration

\[ \text{Newton's Law of Motion} \Rightarrow F = ma \]

- units: NKS \( N = 49 \text{ m/s}^2 \)
- Engl. kp (no mass)

\[ \begin{align*}
\text{larger force} & \quad \text{same mass}, \quad \text{larger acceleration} \\
\text{same force} & \quad \text{larger mass}, \quad \text{smaller acceleration}
\end{align*} \]

- Introduces concept of mass! Mass didn't exist before Newton, only weight.

\[ \text{Gravity} \ a = g \Rightarrow \text{weight} \ W = mg \]

A mass of 1 lb has a weight of 1 kilo = 9.8 N

**ASIDE**

How can use English units to mass?

\[ F = ma = mg \left( \frac{a}{g} \right) = W \left( \frac{a}{g} \right) \text{ "g's"} \]

\[ \Rightarrow \text{force of} \ 1 \text{ lb on} \ 1 \text{-lb weight gives} \ a = g = 32 \text{ ft } \text{s}^{-2} \text{ acceleration. But messy.} \]
List forces, see if "fundamental" or secondary

- gravity "fundamental"
- friction secondary (electric)
- air drag/wind secondary (electric)
- electric "fundamental"
- gas pressure secondary (electric)

**Force Diagrams - Identify Forces on "Isolated" Object**

\[
\begin{align*}
N^1 & \quad N^2 \\
F_{\text{air}} & \quad F_{\text{fr}} \\
F_i & \quad F_i \\
W & \quad W
\end{align*}
\]

- Horizontal: \( a > 0 \) (up) \( (F_i + F_2) - F_{\text{air}} = ma \)
  \( a = 0 \)
- If constant speed \( \Rightarrow F_{\text{air}} = F_i + F_2 \) (huge at high speed)

**Terminal Speed of Falling**

- \( F_{\text{air}} = W \)
  \( \Rightarrow a = 0 \)

- Air flow
- Fairing reduces air drag
  \( \Rightarrow \) higher max speed
**Force Pairs**

"Every action has an equal and opposite reaction"

[Diagram: Person pushing against a wall, neither moves]

- Forces are interaction between objects. Much of physics: describe interaction.

"Action at a distance": Sun $\rightarrow$ $F_{SE}$ $\leftarrow$ Earth

Sun and Earth interact equally.

$F_{ES} = F_{SE}$

Earth and Sun = Sun on Earth

[Diagram: Force arrows showing "Push me / Pull me"]

Can riders move together?