CH 5 - Dynamics = \text{FORCE / Newton} \quad \text{TRANSLATIONAL}

Galileo/Newton: \text{INERTIA = resistance to change}

CH 5-6: \text{translational inertia = resistance to transl. accel.}

CH 10: \text{rotational inertia = resistance to rot. accel.}

Q: What is inertia? A: Do acceleration experiments.

(1) Newton invents concept of "mass" (not weight!)

\text{inertia} \propto \text{mass} \quad \text{(kg)}

\text{mass} \quad \text{in kg}

(2) Newton invents "momentum" \( \vec{p} = m \vec{v} \)

(3) Newton invents "force":

1\text{st Law: if no force } \Rightarrow \vec{p} = \text{constant} \quad \text{An object in motion stays in motion} \quad \text{m/s}

\text{2nd Law: } \vec{F} = \frac{d\vec{p}}{dt} \quad \text{units: \text{kg m/s} = Newton (N)}

\text{English: pounds (lbs)}

If \( m \) = constant \( \Rightarrow \quad \vec{F} = ma \)
**Force Properties:**
- push or pull
- acts on an object
- requires an "agent"
- vector
- contact force or "action at a distance"
  - wind
  - friction
  - bat on ball
  - string on block
  - gravity (201)
  - electric (202)
  - magnetic (202)
  - nuclear (204)

**DEMONS**
- 1F20.20 Smash hand under lead block
- 1F20.22 Pound nail into block on student's head
- 1G10.2D Cart with pulley + weight
- 1F30.30 Cart on cart
- video BMW tabletop - pull string

**Key to solving force/motion problems:**
1. **ISOLATE** object of interest
2. **IDENTIFY** ALL FORCES acting on object
   
   "**Free Body Diagram**"

**Huge example:** Cart + string + pulley + weight

- frictionless
- tension same on both sides

1. (1) isolate weight
   - vertical: $F_w = Mg - T = ma$
   - horizontal: nothing
2. (2) isolate cart
   - vertical $F_v = F_w - mg = ma$
   - horizontal $F_N = mg$
(2) horizontal \( F_h = T = ma \) same as weight!

eliminate \( T \), subst \( T = ma \) into (1)

\[
\frac{Mg - ma}{g} = \frac{M}{m + M} \Rightarrow a = \frac{M}{M + m} g
\]

\[
\Rightarrow T = \frac{m}{M + m} Mg
\]

Note on English units: mass unit not used

\[
W = mg \Rightarrow W = (1 \text{ slug})(32 \text{ ft/s}^2) = 32 \text{ lbs}
\]

Instead, had to use objects weight in general

\[
F = ma \Rightarrow (mg) \frac{\ddot{a}}{g} = W \frac{\ddot{a}}{g} \quad \text{acceleration in "g" units}
\]

\[
\text{objects weight on Earth, lbs}
\]

So, if you weigh 200 lbs, a 200 lbs force on you will accelerate you \( 1 \text{g} = 32 \text{ ft/s}^2 \)

Note: metric unit of weight is kilo

\[
1 \text{ kilo} = \text{weight of } 1 \text{ kg} = (1 \text{ kg}) g = 9.8 \text{ N} = 2.2 \text{ lbs}
\]
Ex: apparent weight of person in elevator accelerating upward

Isolate (1): cab + person

\[ F = T - (M+m)g = (M+m)a \]

Isolate (2): person

\[ F = F_N - mg = ma \] (same \( a \))

\[ a = \frac{T - mg}{M+m} \]

\[ F_N = mg + ma = \text{apparent weight in terms of } a \]

\[ F_N = mg + m \left( \frac{T}{M+m} - g \right) = \frac{m}{M+m} \cdot T \]

\( \text{apparent weight in terms of } T \)