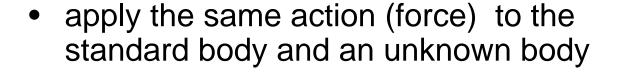
Inertial Mass

- inertial mass is a 'quantity of matter'
- standard body with mass m_s and SI units [kg]
- the mass of all other bodies will be determined relative to the mass of our standard body.







$$\frac{m_u}{m_s} = \frac{a_s}{a_u}$$

Standard Kilogram

 Cylindrical alloy of 90 % platinum and 10 % iridium

 $\rho = 21.56 \,\mathrm{g \cdot cm^{-3}}$

Density and volume of the standard kilogram,

$$V = m/\rho \cong 1000 \text{ g}/22 \text{ g} \cdot \text{cm}^{-3} \cong 46.38 \text{cm}^{3}$$

Constant volume for a cylinder

$$V = \pi r^2 h$$

The surface area

- $A = 2\pi r^2 + 2\pi rh = 2\pi r^2 + \frac{2V}{r}$
- minimize the area with respect to the radius

$$\frac{dA}{dr} = 4\pi r - \frac{2V}{r^2} = 0$$

$$r = h/2$$

radius is one half the height,

$$r = (V/2\pi)^{1/3} \cong 1.95 \text{ cm}$$

Definition: Momentum (Quantity of Motion)

- Momentum is a vector quantity $\vec{\mathbf{p}} = m\vec{\mathbf{v}}$
- Magnitude: product of the mass with the magnitude of the velocity
- Direction: the direction of the velocity
- In the SI system of units, momentum has units

[kg-m-s⁻¹]

Definition: Force

Force is a vector quantity.

$$\vec{\mathbf{F}} \equiv m\vec{\mathbf{a}}$$

- Magnitude of the total force acting on the object is the product of the mass and the magnitude of the acceleration.
- Direction of the total force on a body is the direction of the acceleration of the body.
- SI units for force are [kg-m-s⁻²]
- Unit has been named the Newton 1 N = 1 kg-m-s⁻²

Superposition Principle

Apply two forces $\vec{\mathbf{F}}_{\!\!1}$ and $\vec{\mathbf{F}}_{\!\!2}$ on a single body

Total force is the vector sum of the two forces

$$\vec{\mathbf{F}}^{total} = \vec{\mathbf{F}}_1 + \vec{\mathbf{F}}_2$$

Average Impulse

Apply an average force $\overline{\vec{\mathbf{F}}}$ for an interval of time Δt

Average impulse is the product of the average force and the time interval

$$\overline{\overline{\mathbf{I}}} = \overline{\overline{\mathbf{F}}} \Delta t$$

Units for impulse are the same as for momentum

$$[kg-m-s^{-1}] = [N-s]$$

Impulse

When force is applied continuously over a time interval

$$\left[t_0,t_f\right]$$

Impulse is the integral

$$\vec{\mathbf{I}} = \int_{t_o}^{t_f} \vec{\mathbf{F}} dt$$

Newton's Second Law

The change of momentum is equal to the applied average impulse

$$\mathbf{\vec{\bar{I}}} = \mathbf{\vec{\bar{F}}} \Delta t = \Delta \mathbf{\vec{p}}$$

For an instantaneous action of the total force, force is equal to the product of mass with acceleration.

$$\vec{\mathbf{F}}^{total} = \lim_{\Delta t \to 0} \frac{\Delta \vec{\mathbf{p}}}{\Delta t} \equiv \frac{d\vec{\mathbf{p}}}{dt}$$

When the mass remains constant in time,

$$\vec{\mathbf{F}}^{total} = m\vec{\mathbf{a}}$$