DYNAMICS

1st Newton's law. - Law of inertia. -
At object at rest will remain at rest unless acted on by an unbalanced force.

"Provides the definition of force"

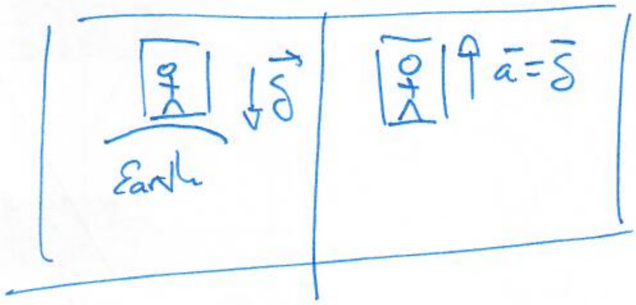
2nd Newton's law. -
An acceleration is produced when a force acts on a mass.

$$\bar{a} = \frac{\bar{F}}{m}$$

$m \equiv$ intertial mass. $\equiv m_i$

m_i seems to agree with gravitational mass

Einstein: it is impossible to distinguish uniform acceleration and an uniform gravitational field. -



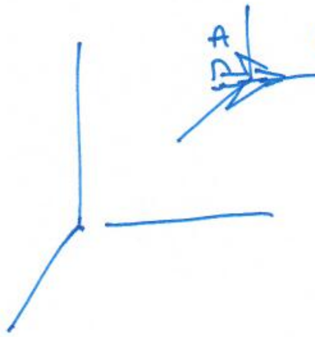
3rd Newton's law

For every action there is an equal and opposite reaction. -

"if a body A pushes a force on B, B exerts an equal force but reversed on A"

Reference frame: a set of coordinates at rest with respect to what is observed.-

Inertial reference frame: - A reference frame where the 1st law is observed.-



v constant
$a = 0$

is inertial

The first law allows to check if a reference frame is inertial or not.-

$v \neq$ constant
$a \neq 0$

$\downarrow$

The observer in A checks if a ball moves like there is a 'fictitious' force or not.-

- The passenger feels a force against the seat or not

Basic forces
- gravitational
- electro-magnetic
- nuclear - strong
- nuclear - weak

Action at distance forces :-> concept of 'field'
linked to a 'carrier particle'
" " " 'wave' → field

Ad-hoc classification

(I) Action at distance forces
- gravitational
- electrical
- magnetic

(II) Contact forces.
- Frictional forces
- Tension forces
- Normal forces
- Spring forces

Normal forces — the support force exerted upon an object that is in contact with another object.-

$\perp$ to surface

$|\vec{W}| = |\vec{N}|$

Friction force — the support force exerted by a surface as an object moves across it (dynamic / kinetic) or makes an effort to move it (static)

∥ to surface of contact.-

A special case: fluid resistance between layers = viscosity

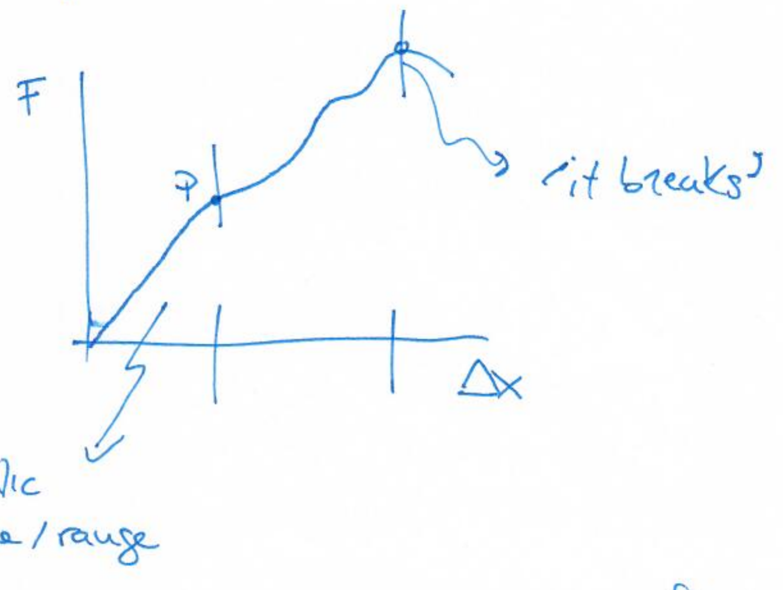
Spring force

Hooke's law forces:-
Exerted by compressed / streched spring

$F = -K\Delta x$

$x \ll$ elastic range

P = Point of non-elasticity
"yield strength"



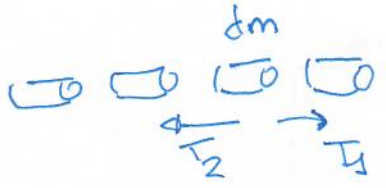
stress at which the material begins to deform plastically.-

1D $F = -Kx$

3D $\begin{pmatrix} F_1 \\ F_2 \\ F_3 \end{pmatrix} = \begin{pmatrix} K_{11} & K_{12} & K_{13} \\ K_{21} & K_{22} & K_{23} \\ K_{31} & K_{32} & K_{33} \end{pmatrix} \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix}$

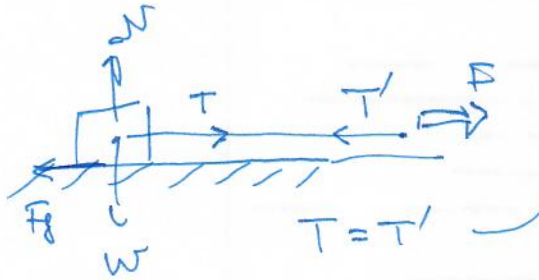
$\vec{x}$ deformation
$\vec{F}$ resulting force.-

Tension force — Force transmitted through a string / rope / cable / ... when pulled.-



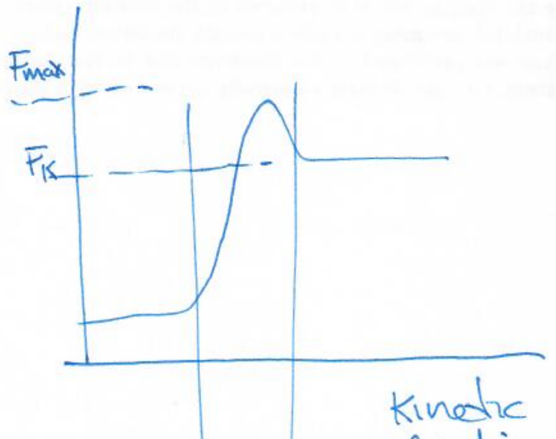
- directed along the lenght of the wire
- pulls are equal on opposites sides of the wire.-

$$(T_2 - T_1) = (dm)\, a$$



$a = 0 \to$ it does ~~not~~ compress neither stretches.

Discussion on Friction forces



$$F_{static} \le \mu_s F_n$$

$$\underset{\text{kinetic}}{F_{sliding}} = \mu_K F_n$$

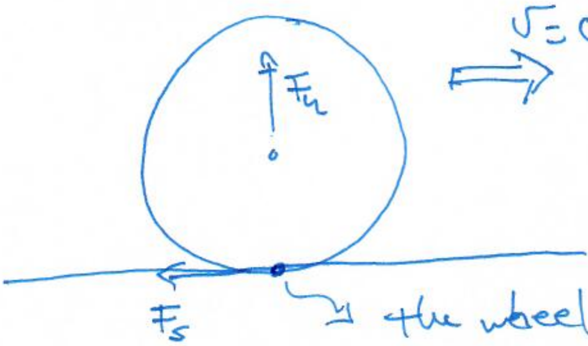
μ_s = coefficient of friction static

μ_K = coefficient of friction kinetic

static friction regime
↓
due to interlocking asperities (mainly)

kinetic friction regime
↓
due to chemical bonding between surfaces (mainly).

Rolling without sliding



$F_s \equiv$ friction 'static'

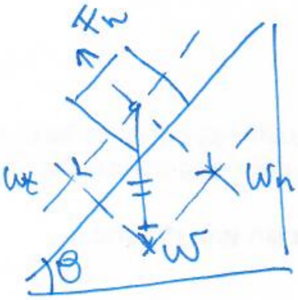
$F_s = \mu_s F_n$

the wheel rolls, but the contact point of the wheel is stationary with respect of the contact point of the ground

$F_{\substack{max \\ static}} > F_{kinetic}$ avoid braking with blocked breaks.-

Examples

Example #1



$W_t = ma_t$; $a_t m = mg\sin\theta$

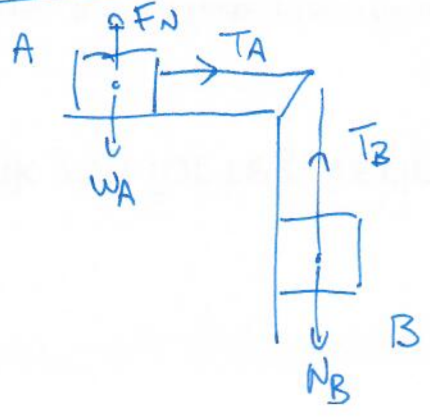
$a_t = g\sin\theta$

$F_n = W_n$

$0 = ma_n = m F_n$

$F_n = mg\cos\theta$

Example #2



$$A : \begin{cases} T_A = m_A a_A \\ F_N = W_A \end{cases}$$

$$B : \begin{cases} W_B - T_B = m_B a_B \end{cases}$$

$T_B = -m_B a_B + m_B g$

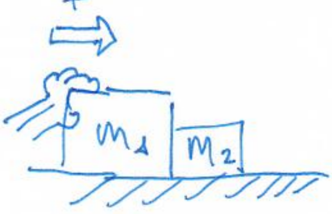
$T_A = T_B = T \qquad a_A = a_B = a$

$$\begin{cases} A: & T = m_A a \\ B: & T = -m_B a + m_B g \end{cases}$$

$$m_A a = m_B g - m_B a$$

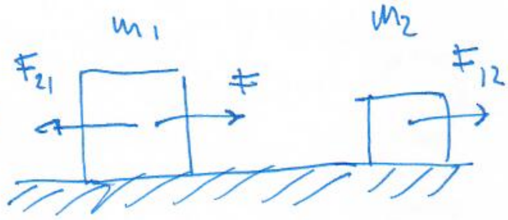
$$\boxed{a = \frac{m_B}{m_A + m_B} \cdot g}$$

Example #3



$\mu = 0$

$\equiv$



$a_1 = a_2$ because they're in contact.

$$F - F_{21} = m_1 a$$
$$F_{12} = m_2 a$$

$$F - m_1 a = m_2 a$$
$$\boxed{a = \frac{F}{m_1 + m_2}}$$

it's like moving a big mass $(m_1 + m_2)$

The morale of the story: we can neglect the internal forces and consider a set of small bodies like a single big one.-