

DYNAMICS

1st Newton's law - law of inertia -

An object at rest will remain at rest unless acted on by an unbalanced force.

'Provides the definition of force'

2nd Newton's law -

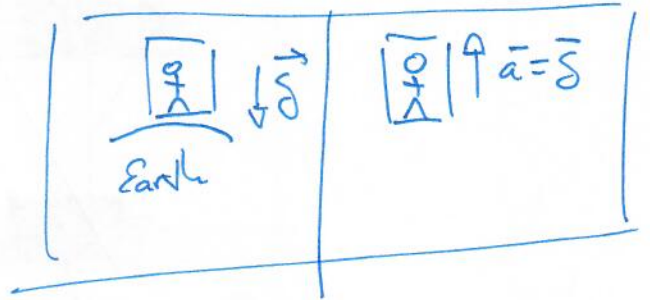
An acceleration is produced when a force acts on a mass.

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

$m \equiv$ inertial 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

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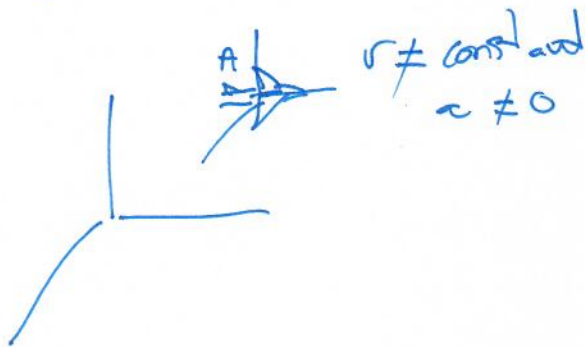
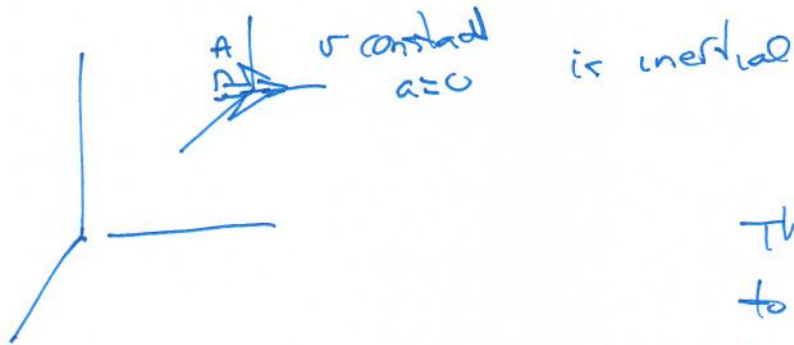
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reversed on A'

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. -



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

↓
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



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Basic forces

- gravitational
- electro-magnetic
- nuclear - strong
- nuclear - weak

Action at distance forces \rightarrow concept of 'field'
 linked to a 'carrier particle'
 " " " 'wave' \rightarrow field

Ad-hoc classification

Ⓘ Action at distance forces

- gravitational
- electrical
- magnetic

Ⓜ 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.

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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 / stretched spring

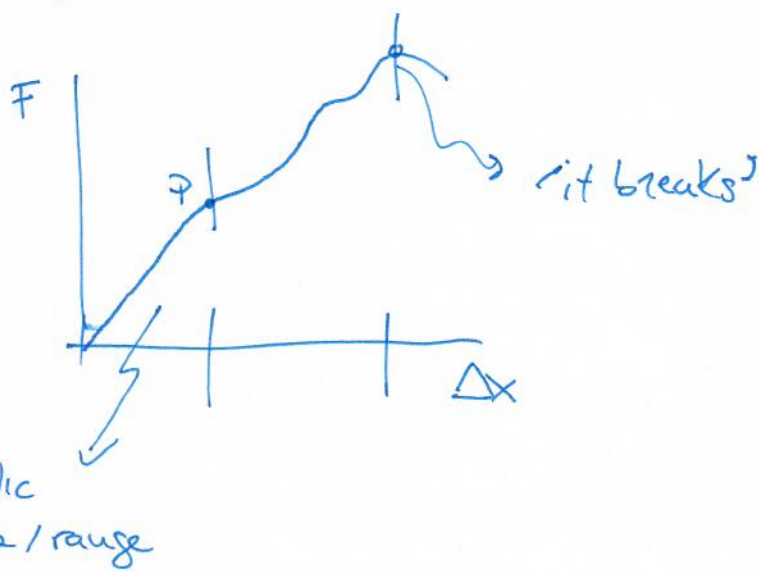
$$F = -k \Delta x$$

$x \ll$ elastic range

$\underline{P} \equiv$ Point of non-elasticity
'yield strength'



stress at which the material begins to deform



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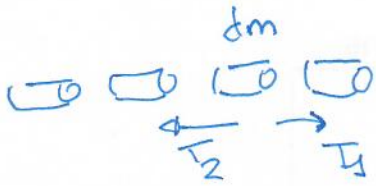
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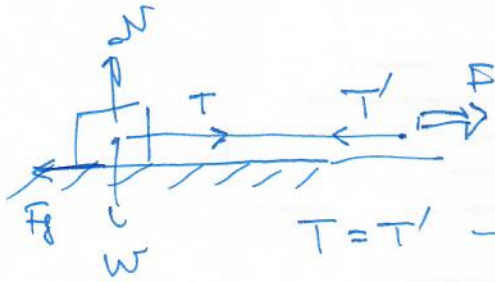
$(F_1, F_2, F_3, F_4, F_5)$ $(K_1, K_2, K_3, K_4, K_5)$ $(x_1, x_2, x_3, x_4, x_5)$

Tension force

force transmitted through a string / rope / cable (... when pulled) -



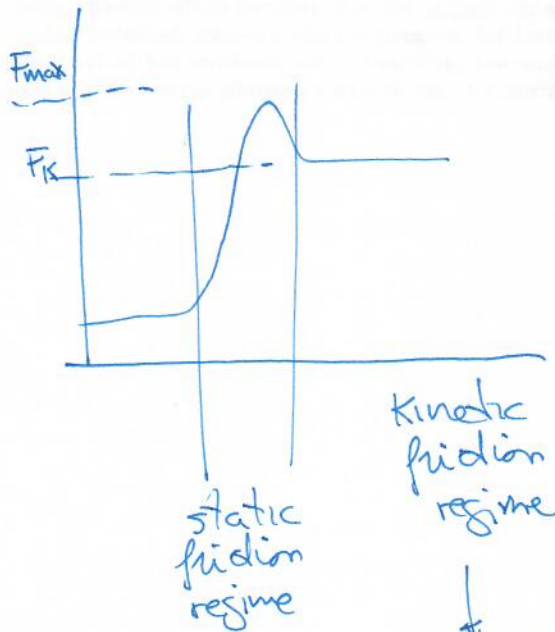
- directed along the length of the wire
- pulls are equal on opposite sides of the wire -



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

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

Discussion on Friction forces



$$F_{\text{static}} \leq \mu_s F_n$$

$$F_{\text{sliding kinetic}} = \mu_k F_n$$

μ_s = coefficient of friction static

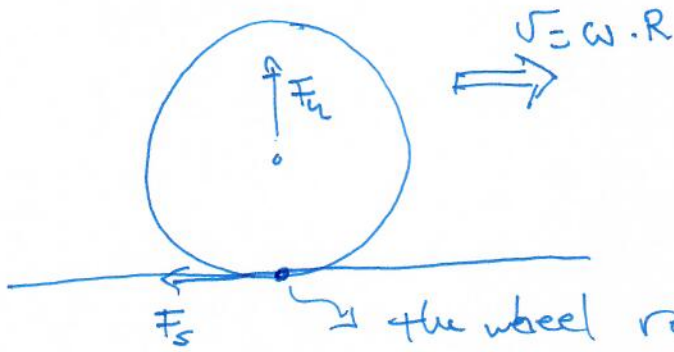
μ_k = coefficient of friction kinetic

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Rolling without sliding



$F_s \equiv$ friction 'static'

$$F_s = \mu_s F_n$$

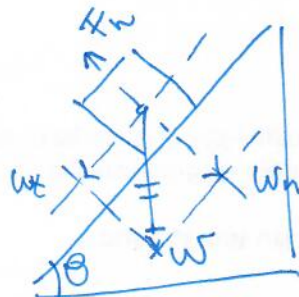
the wheel rolls, but the contact point of the wheel is stationary with respect of the ground

$$F_{\text{max static}} > F_{\text{kinetic}}$$

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

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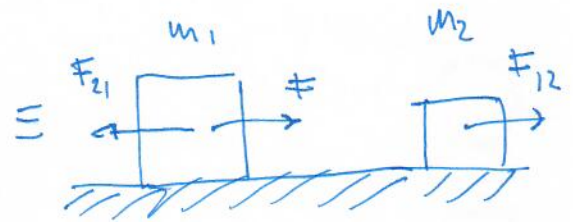
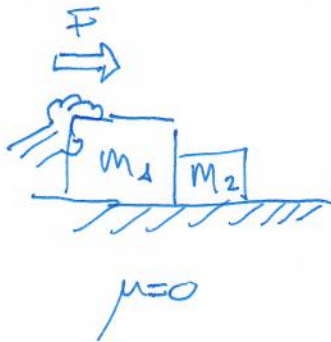
$$T_A = T_B = T \quad a_A = a_B = a$$

$$\begin{array}{l} A \\ B \end{array} \left\{ \begin{array}{l} T = m_A a \\ T = -m_B a + m_B g \end{array} \right.$$

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

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

Example #3



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

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

$$F_{12} = m_2 a$$

$$F - m_1 a = m_2 a$$

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

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 system like a single big

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