Mechanics I

velocity ≠ speed
↓ vector — ↓ scalar

displacement, velocity, acceleration are all vectors

graphs: s-t / v-t / a-t → be careful, look at the axes!

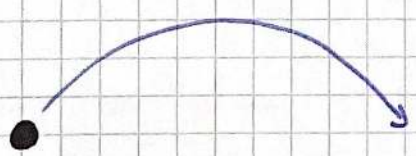
The IB likes to use v for current velocity and
u for initial velocity

uniformly accelerated motion:

$v = u + at$ (speed gain)	$s = ut + \frac{1}{2}at^2$
$s = \left(\frac{u+v}{2}\right) \cdot t$ (avg speed)	$s = vt + \frac{1}{2}at^2$
$v^2 = u^2 + 2as$	

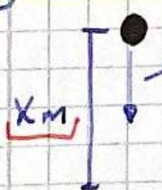
→ e.g. free-fall
- without air resistance, same accelaration for all objects, indefinetely
- with air resistance the object reaches some terminal velocity (max. velocity)

projectile motion



- parabola
- independent vertical and horizondal components
  - vertical ↓ acceleration by gravit. field
  - horizondal ↓ const

E determine free-fall acceleration



→ needs y time → direct measurement

or distance senses + data logger
or video analysis

Forces

$N = \frac{kg \cdot m}{s^2}$

force → acceleration
force → deformation

force:
- object that exerts
- object on which it acts
- magnitude
- direction
- → vector

Hooke's law → extension of spring ~ force acting on it
→ k is spring constant

(if at rest, stays at rest. if moving, keeps moving)

Newton's first law → "if don't push, don't move" (or stay at const speed)

$F_{res} = 0 \iff v = const$

(translational) equilibrium → resultant/net force is zero

forces types: gravitational, electrostatic, magnetic, friction, tension, normal reaction

Newton's second law → resultant force is proportional to the rate of change of momentum

$F = \frac{\Delta p}{\Delta t}$ or $F = m \cdot a$
↓
const force on const mass

Newton's third law → "actio = reactio"

A on B → B on A → equal and opposite and same type

$F_{A\ on\ B} = -F_{B\ on\ A}$

Mass and weight

"weight" = gravitational force = $F_G = m \cdot g$
↑
mass

$g_{earth} \approx 10\ N/kg$

$g_{moon} \approx 1,6\ N/kg$

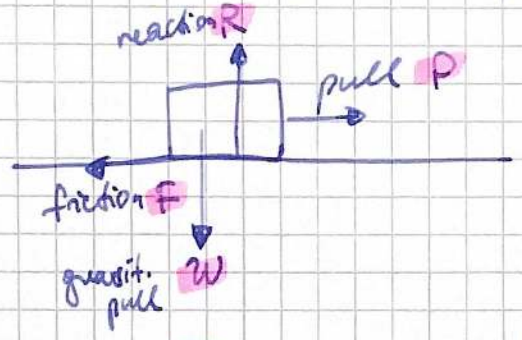
Solid friction

- if not moving: static friction
- if moving: dynamic/kinetic friction → F_k

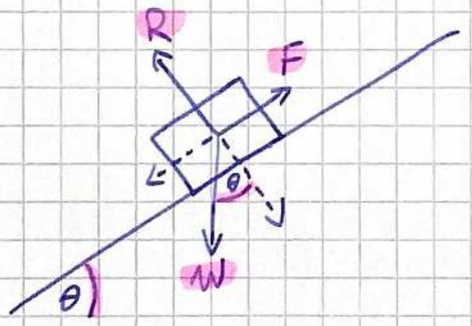
not moving until push exceeds F_{max}

$$F_{max} > F_k$$

coefficient of friction μ (no units)



$$F_{max} = \mu \cdot R$$



$$F = W \cdot \sin(\theta)$$

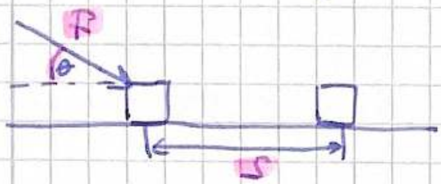
$$R = W \cdot \cos(\theta)$$

$$\mu = \frac{F_{max}}{R} = \frac{W \cdot \sin(\theta)}{W \cdot \cos(\theta)} = \tan(\theta)$$

↑ when block just starts moving

Work, Energy and Power

Work is only done if a force moves its point of application in the direction of the force.
(const velocity without friction → no work done)



$W = F \cdot s \cdot \cos(\theta)$

$[W] = J = N \cdot m$

$W_{lift} = m \cdot g \cdot h$

$W_{spring} = \frac{1}{2} \cdot k \cdot \Delta x^2$

- W_{spring}: compress/extend
- k: spring const, $[k] = \frac{N}{m}$
- Δx: extension/contraction

Work = energy transferred

$W_{kin} = \frac{1}{2} m v^2$

$W_{gr.\ pot.} = m \cdot g \cdot h$

$W_{elastic\ pot.} = \frac{1}{2} \cdot k \cdot \Delta x^2$

„Leistung" Power $P = \frac{W}{t}$ "work per time"

moving at const velocity v on const friction F
→ $P = F \cdot v$

„Wirkungsgrad" Efficiency $\eta = \frac{\text{useful work OUT}}{\text{total work IN}} = x\ \%$

(η: Eta)

Momentum and impulse

„Impuls" momentum $\vec{p} = m \cdot \vec{v}$ "Big object more momentum at same speed"

„Kraftstoß" impulse $J = \Delta p = F \cdot \Delta t$