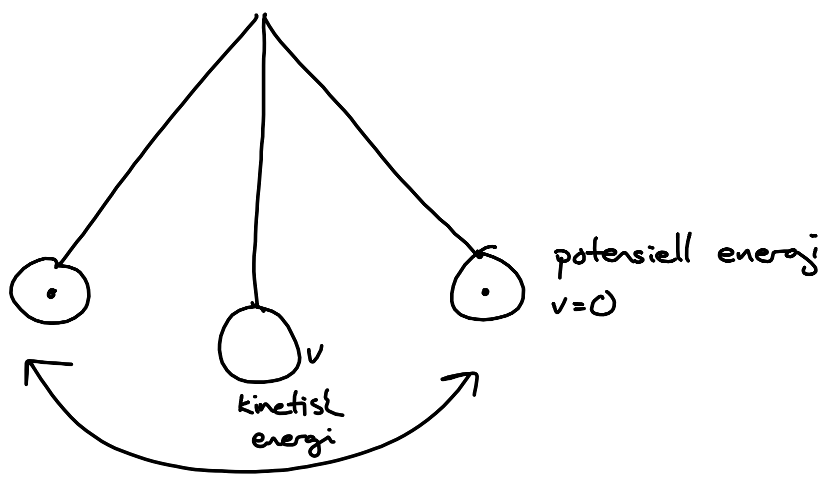
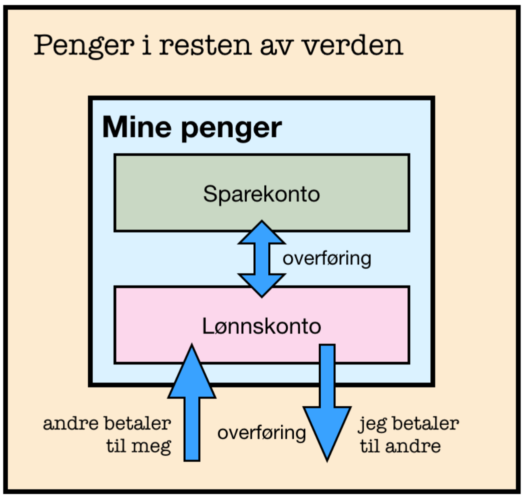
February 4, 2019

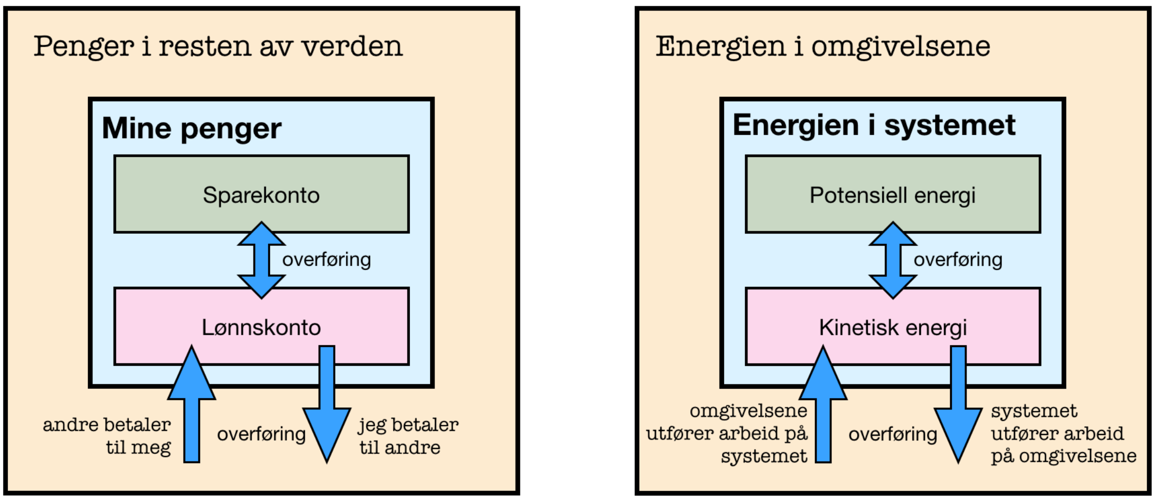
Blir han knust?

Energi




Penger i resten av verden
Mine penger
Sparekonto
overføring
Lønnskonto
andre betaler til meg
overføring
jeg betaler til andre

February 4, 2019



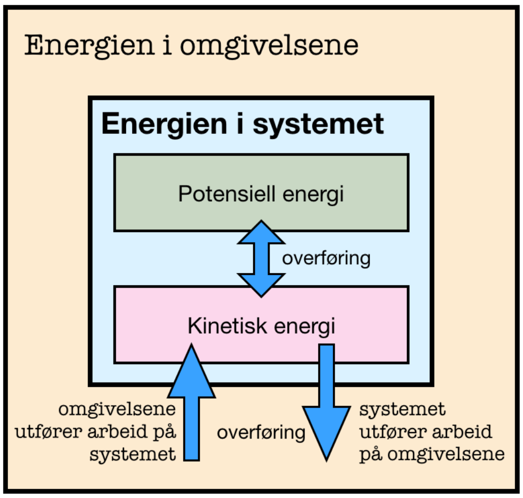
Bilde: Wikimedia - Tyssedal_rørgate.jpg

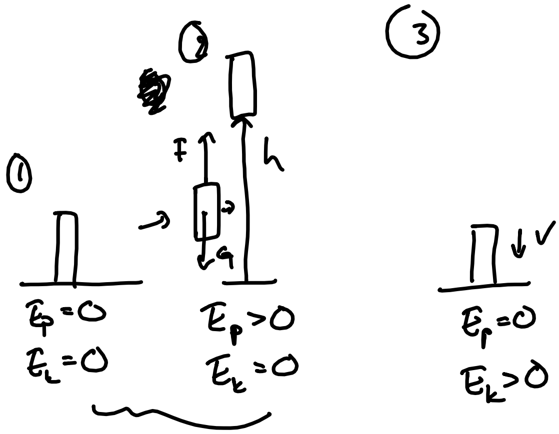
I et vannkraftverk utnytter vi den potensielle energien i vann som er lagret høyt oppe.

Vindturbiner utnytter den kinetiske energien i luft i bevegelse.

Bilde: Wikimedia - Smøla.jpg

Arbeid = overføring av energi





arbeid
fra meg på flaska

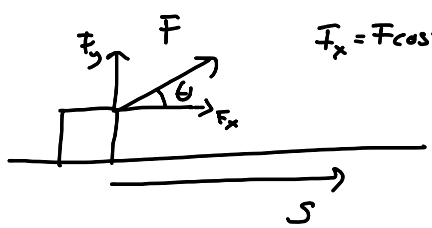
$$W = F \cdot s$$

arbeid = kraft × strekning
i samme retning

$[W] = Nm$
$= J$ (joule)

arbeid (prosess)
energi (egenskap)

På skrå:

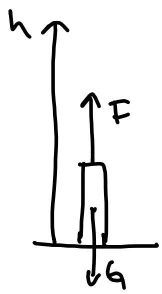


$F_x = F\cos\theta$

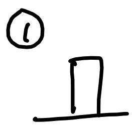
$W = Fs\cos\theta$

Potensiell energi

løfte noe til høyde h



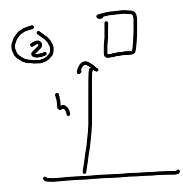
$W = Fh = mgh$



$E_p = 0$

$E_k = 0$

$E_1 = 0$



$E_2 = E_{p,2} + \not{E_k}$

$\Sigma F_y = 0$

$F = G = mg$

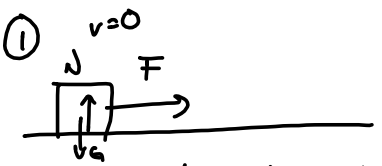
$E_2 = \not{E_1} + W$

$E_{p,2} = W = mgh$

$$\boxed{E_p = mgh}$$

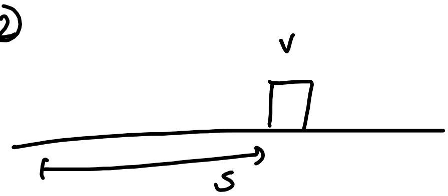
Kinetisk energi

①



ingen andre krefter i x-retning

②



$$E_2 = E_1 + W$$

$$E_{k2} = 0 + W$$

$$W = Fs$$

$$F = ma$$

$$v^2 - \cancel{v_0^2} = 2as$$

$$v^2 = 2as \qquad a = \frac{F}{m}$$

$$v^2 = \frac{2(Fs)}{m}, \quad Fs = W$$

$$v^2 = \frac{2W}{m}$$

$$W = \frac{1}{2}mv^2$$

$$\boxed{E_k = \frac{1}{2}mv^2}$$

Effekt

Energi per tid

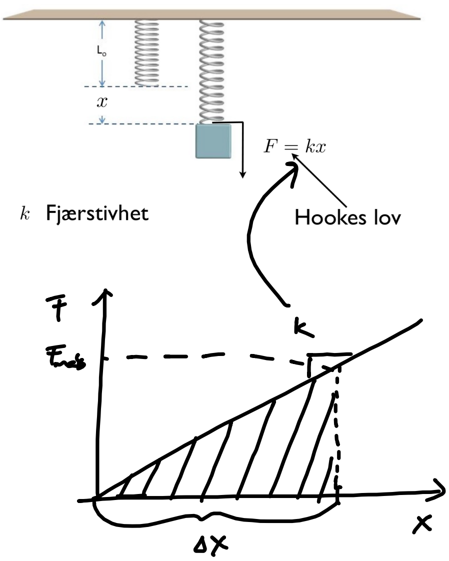
Effekt $P = \frac{W}{\Delta t}$

$[P] = \frac{J}{s} = W$ Watt

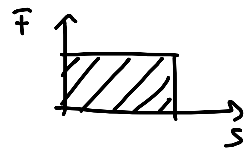
NB! Arbeid W størrelse $[W] = J$

Watt W enhet $[P] = W$

Elastisk potensiell energi



$(W = Fs)$



$$W = \frac{1}{2} F_{maks} \Delta x$$

$$F_{maks} = k \Delta x$$

$$W = \frac{1}{2} k (\Delta x)^2$$

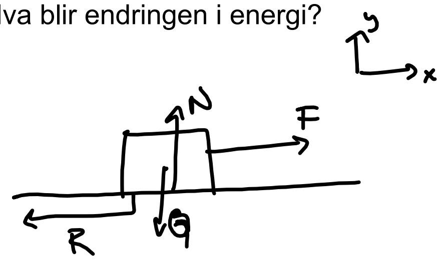
$$\boxed{E_{p,e} = \frac{1}{2} k (\Delta x)^2}$$

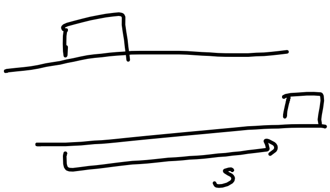
Du trekker et barn på akebrett bortover veien med konstant fart.

a) Tegn kreftene som virker

b) Hvilket arbeid gjør du på akebrettet?

c) Hva blir endringen i energi?



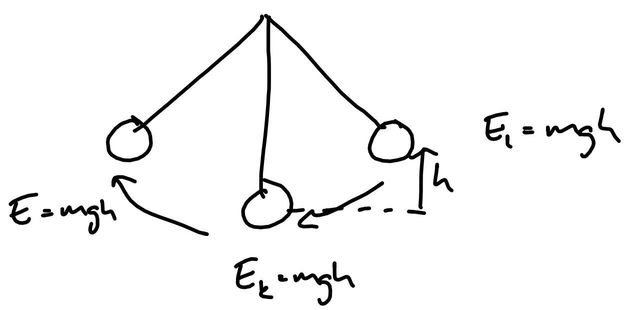


$$W_F = Fs$$

$$W_R = -Rs$$

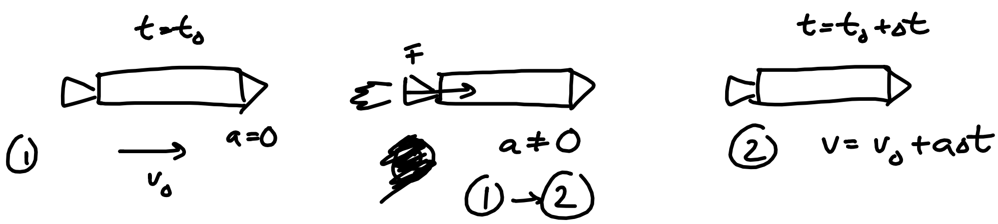
$$\Delta E = W_F + W_R = 0$$

Blir han knust?




Hvordan skal den få tak i insektet?

Impuls og bevegelsesmengde



Hva blir v?

$v = v_0 + a\Delta t$

$\underbrace{v - v_0}_{\Delta v} = a\Delta t$

$F = ma$

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

$\Delta v = \frac{F}{m}\Delta t = \frac{F\Delta t}{m}$

$\underbrace{F\Delta t}_{\text{impuls}} = \underbrace{m\Delta v}_{\text{endring i bevegelsesmengde}}$

impuls = endring i bevegelsesmengde

$I = \Delta p$

bevegelsesmengde

$\vec{p} = m\vec{v}$

Samsnakk: Du slipper en stor og en liten stein ned fra en høyde. Hvilken stein har størst bevegelsesmengde når den når bakken?

$G = mg = ma$

$I = \Delta p$

$F \Delta t = m \Delta v$

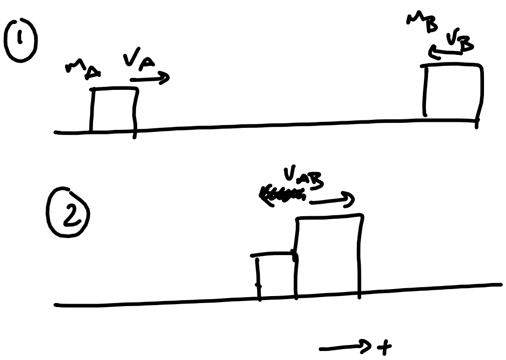
$G_s > G_e$ (F), lik (Δt), $m_s > m_e$ (m), lik (Δv)

$I_s > I_e$

$\Delta p_s > \Delta p_e$

Samsnakk: To biler frontkolliderer. Den første bilen veier 1200 kg og kjører i 90 km/t, den andre bilen veier 1800 kg og kjører i 80 km/t. Kollisjonen gjør at bilene henger seg sammen. Veien er islagt (null friksjon).

Vil bilene bevege seg etter kollisjonen? I hvilken retning? Hvordan kan vi finne ut hva farten blir?



$$F_{AB} = -F_{BA}$$

$$\Delta t_A = \Delta t_B$$

$$I_A = -I_B$$

$$\Delta p_A = -\Delta p_B$$

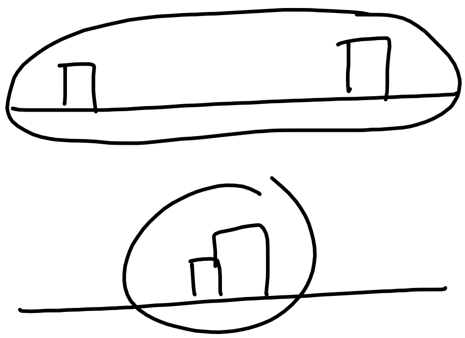
$$m_A v_{AB} - m_A v_A = -\left(m_B v_{AB} - (-m_B v_B)\right)$$

$$m_A v_{AB} - m_A v_A = -m_B v_{AB} - m_B v_B$$

$$v_{AB} = \frac{m_A v_A - m_B v_B}{m_A + m_B} = -12 \text{ km/t}$$

Bevaring av bevegelsesmengde

begge biler som system



$p_1 = m_A v_A - m_B v_B$

$I = 0$

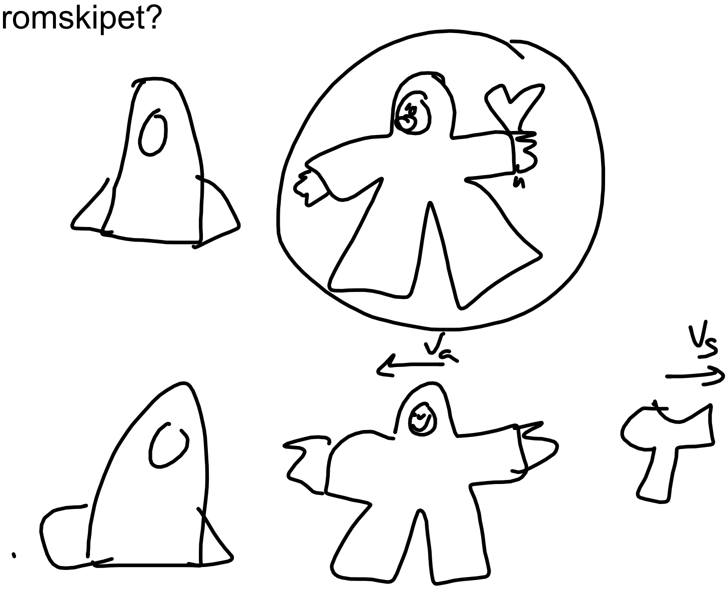
$\Delta p = 0$

$p_2 = (m_A + m_B) v_{AB}$

$p_1 = p_2$

Samsnakk:

Du er en astronaut som er ute for å reparere romskipet ditt. Forankringen bryter og du flyter ut i rommet med bare en skiftenøkkel i hånden. Hvordan skal du komme deg tilbake til romskipet?



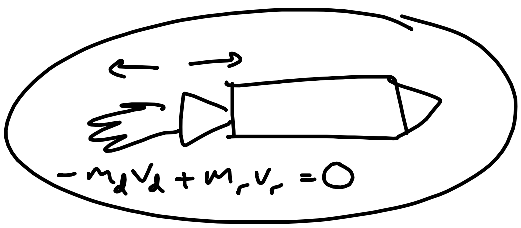
$p_1 = 0$

$I = 0$

$p_2 = 0$

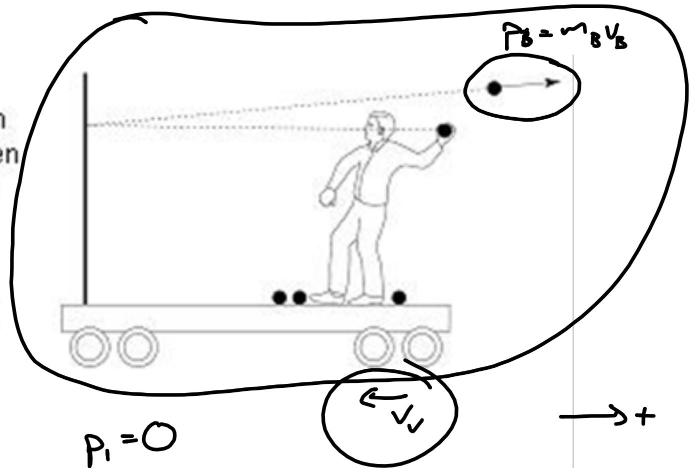
$= -m_a v_a + m_s v_s = 0$

Rakett i verdensrommet



Du står på en vogn som er i ro på et friksjonsfritt spor. Du kaster en ball i en vegg som er festet i vognen. Hvis ballen spretter tilbake som vist på figuren blir da vognen satt i bevegelse?

1. Ja, den beveger seg mot høyre.
2. Ja, den beveger seg mot venstre.
3. Nei, den forblir i ro.



$p_1 = 0$

$I = 0$

$p_2 = 0 = m_B v_B - m_v v_v$

Du kaster en snøball og en sprettball mot en vegg. De to har samme masse og får samme utgangsfart.

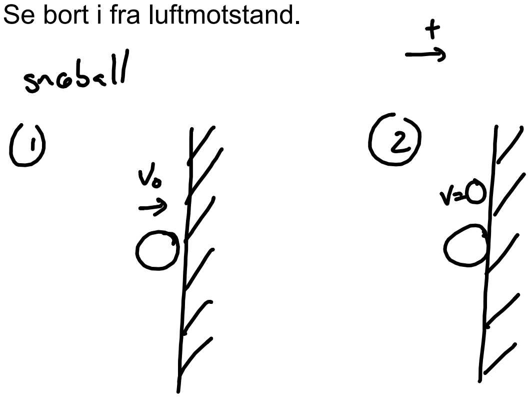
Snøballen setter seg fast i veggen, mens sprettballen spretter tilbake med halvparten så stor fart som den hadde i utgangspunktet.

Hva er forskjellen i impuls for de to i sammenstøtet med veggen?

Se bort i fra luftmotstand.

Impuls

snøball



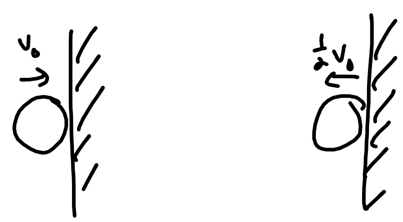
$$I = \Delta p$$

$$F\Delta t = m\Delta v$$

$$= m \cdot 0 - mv_0$$

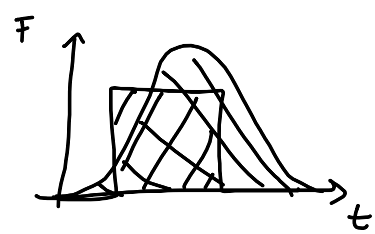
$$I = F\Delta t = -mv_0$$

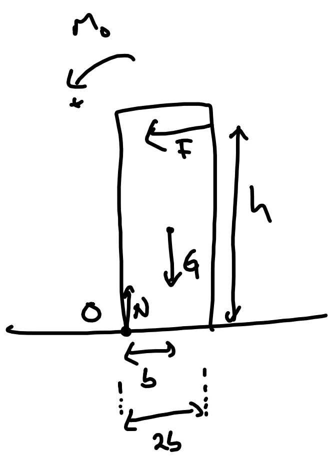
sprettball



$$I = F\Delta t = -\frac{1}{2}mv_0 - mv_0$$

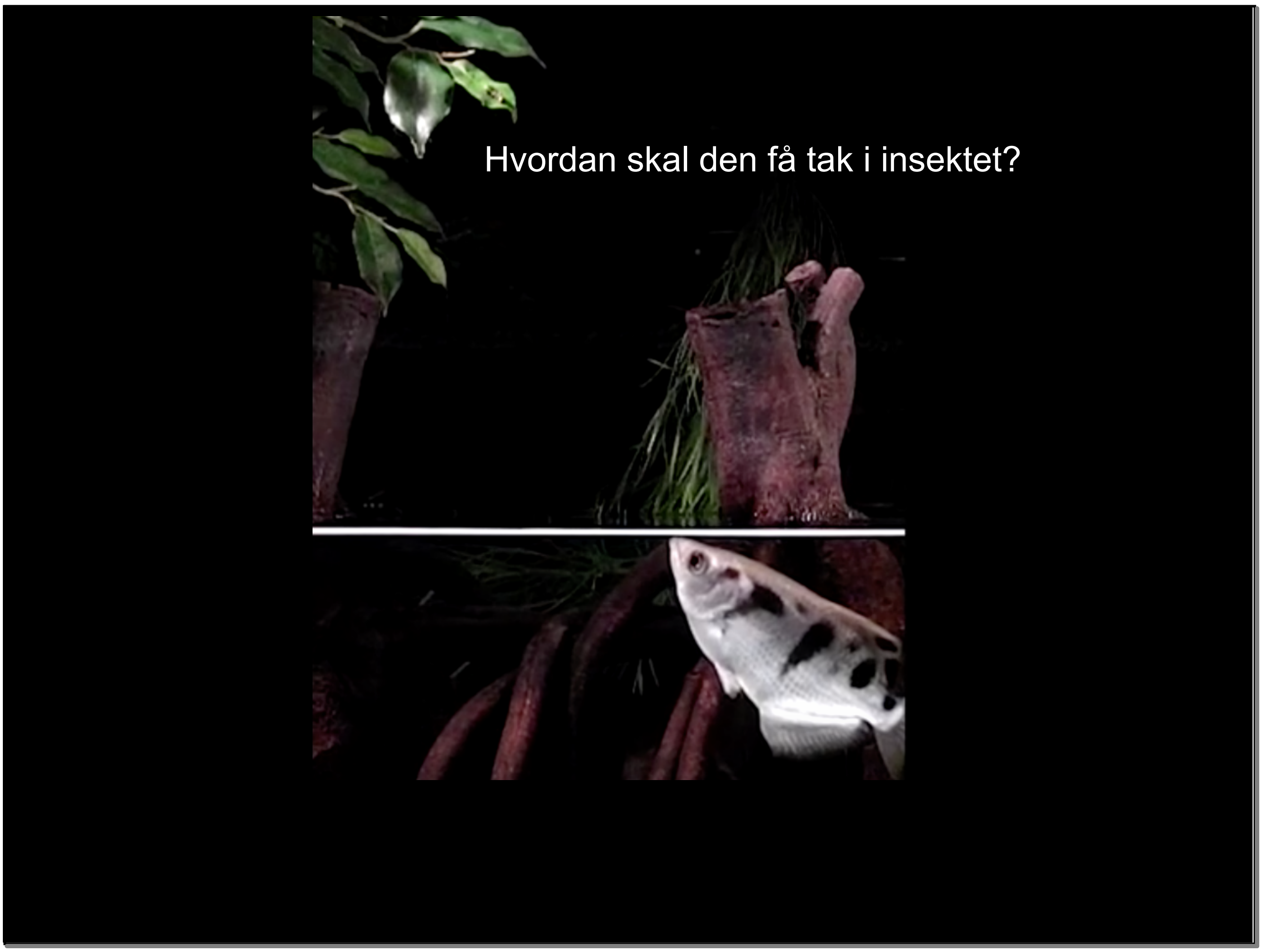
$$= -\frac{3}{2}mv_0$$





$$\Sigma M_0 = Fh - Gb = 0$$

$$F = \frac{Gb}{h}$$


Hvordan skal den få tak i insektet?

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How Archer Fish Achieve a Powerful Impact: Hydrodynamic Instability of a Pulsed Jet in *Toxotes jaculatrix*

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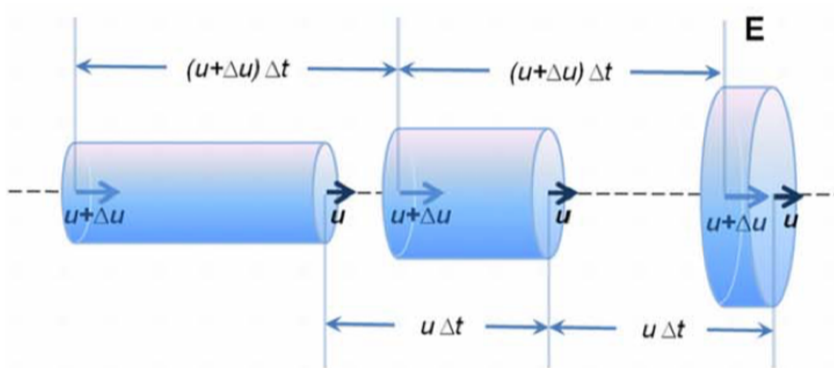
Abstract

Archer fish knock down insects anchored to vegetation by hitting them with a precisely aimed jet of water. The striking force of the jet at the impact is such to overcome the strong anchoring forces of insects. The origin of the effectiveness of such hunting mechanism has been long searched for inside of the fish, in the unsuccessful attempt to identify internal structures dedicated to the amplification of muscular power. Here we perform a kinematic analysis of the jet emitted by two specimens of *Toxotes jaculatrix*. We estimate that at the impact the jet conveys a typical specific power of about 3000 W/kg, which is well above the maximum specific power of the order of 500 W/kg deliverable by a vertebrate muscle. Unexpectedly, we find that the amplification of muscular power occurs outside of the fish, and is due to a hydrodynamic instability of the jet akin to those occurring in Drop-on-Demand inkjet printing. The investigated fish are found to modulate the velocity of the jet at the orifice to favor the formation of a single, large, water drop that hits the prey abruptly with a large momentum. The observed mechanism represents a remarkable example of use of an external hydrodynamic lever that does possibly not entail the high evolutionary cost needed for the development of highly specialized internal structures dedicated to the storing of mechanical energy.

Citation: Vailati A, Zinnato L, Cerbino R (2012) How Archer Fish Achieve a Powerful Impact: Hydrodynamic Instability of a Pulsed Jet in *Toxotes jaculatrix*. PLoS ONE 7(10): e47867. doi:10.1371/journal.pone.0047867


E
(u+Δu) Δt
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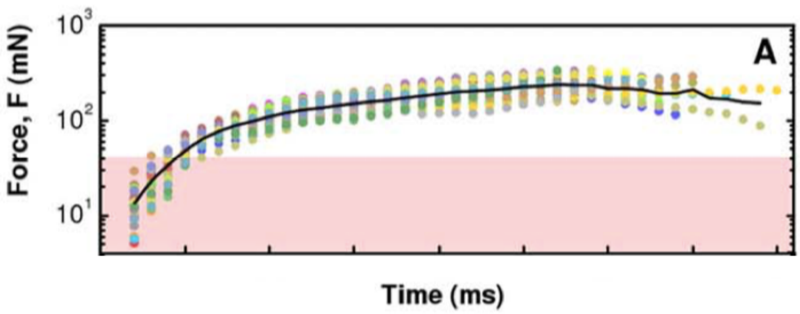
Force, F (mN)
10^3
10^2
10^1
A
Time (ms)