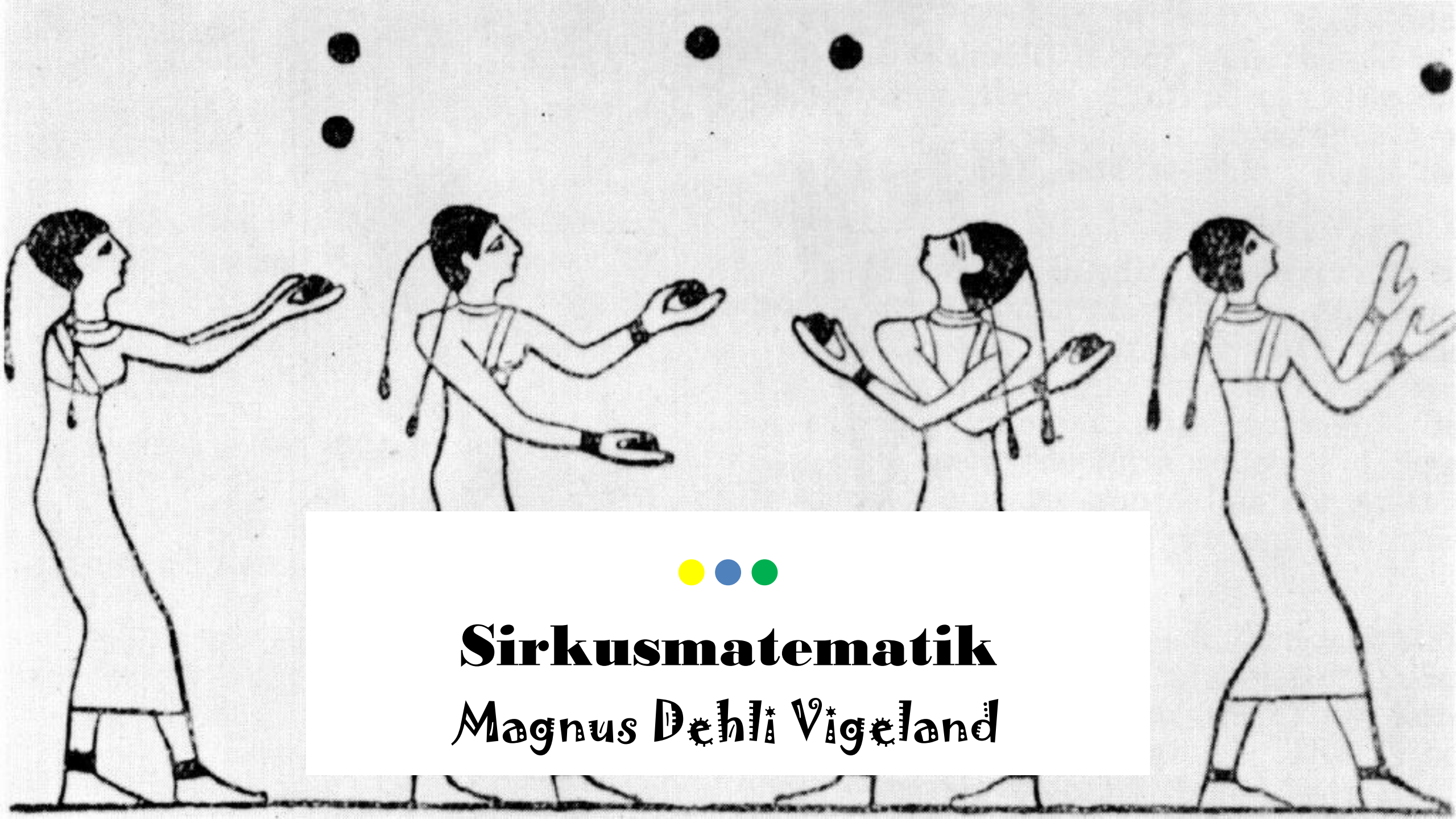
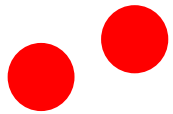


# Sirkusmatematik

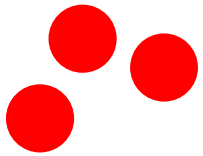
Magnus Dehli Vigeland


IBM



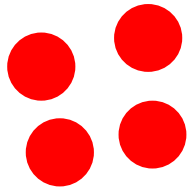
**2 bolde**

| |
|---|
| 31 |
| 501 |



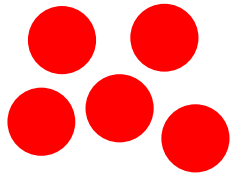
**3 bolde**

| |
|---|
| 441 |
| 51 |
| 531 |
| 60 |
| 73131 |



**4 bolde**

| |
|---|
| 53 |
| 534 |
| 633 |
| 71 |
| 7333 |



**5 bolde**

| |
|---|
| 5 |
| 744 |

## Teorem

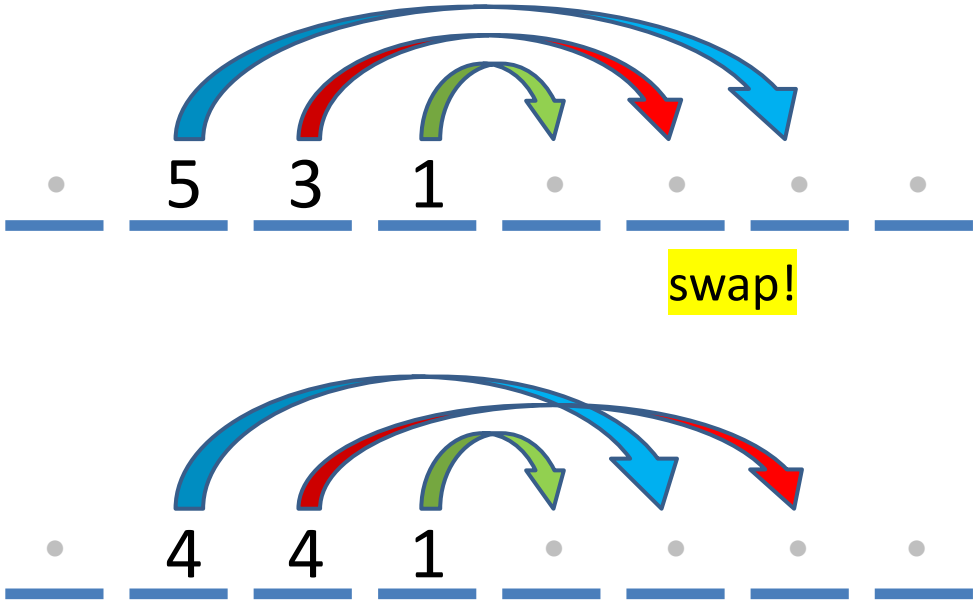
Gennemsnit

?

antal bolde

**Teorem:**
Gennemsnit = # bolde

# Skitse av bevis




Gennemsnittet er uendret!

531 → 441 → 423 → 333

# DET OMVENDTE PROBLEM

- Tag en tallrekke: **5 2 2 1 5**

$$\frac{5+2+2+1+5}{5} = 3 \text{ bolde}$$

- Kan dette jongleres??

**Svar: Nei** . . . 5 2 2 1 5 . . .

- Men hva hvis vi permuterer?

**Svar: Ja!** **5 2 5 1 2**

**Dette er alltid mulig!**
Bevist av matematikeren Hall i 1952.

Proceedings of the American Mathematical Society

1952

## A COMBINATORIAL PROBLEM ON ABELIAN GROUPS

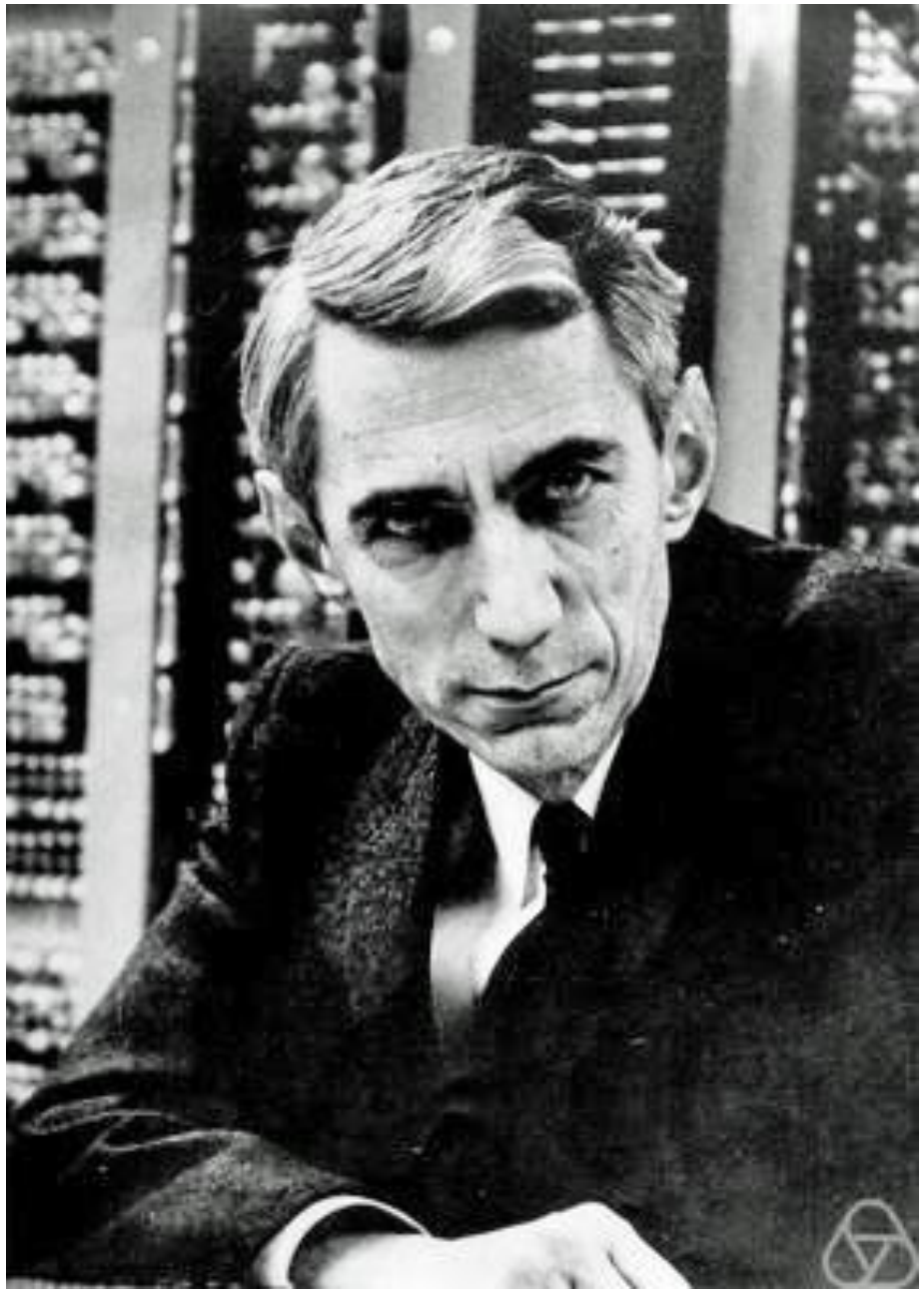
MARSHALL HALL, JR.

1. **Introduction.** Suppose we are given a finite abelian group $A$ of order $n$, the group operation being addition. If

$$\begin{pmatrix} a_1, & a_2, & \cdots, & a_n \\ c_1, & c_2, & \cdots, & c_n \end{pmatrix}$$

is a permutation of the elements of $A$, then the differences $c_1 - a_1 = b_1, \cdots, c_n - a_n = b_n$ are $n$ elements of $A$, not in general distinct, such that $\sum_{i=1}^{n} b_i = \sum_{i=1}^{n} c_i - \sum_{i=1}^{n} a_i = 0$, since the sum of the $c$'s and the sum of the $a$'s are each the sum of all the elements of $A$. The problem is to show that conversely given a function $\phi(i) = b_i$,

Claude Shannon (1916 - 2001)



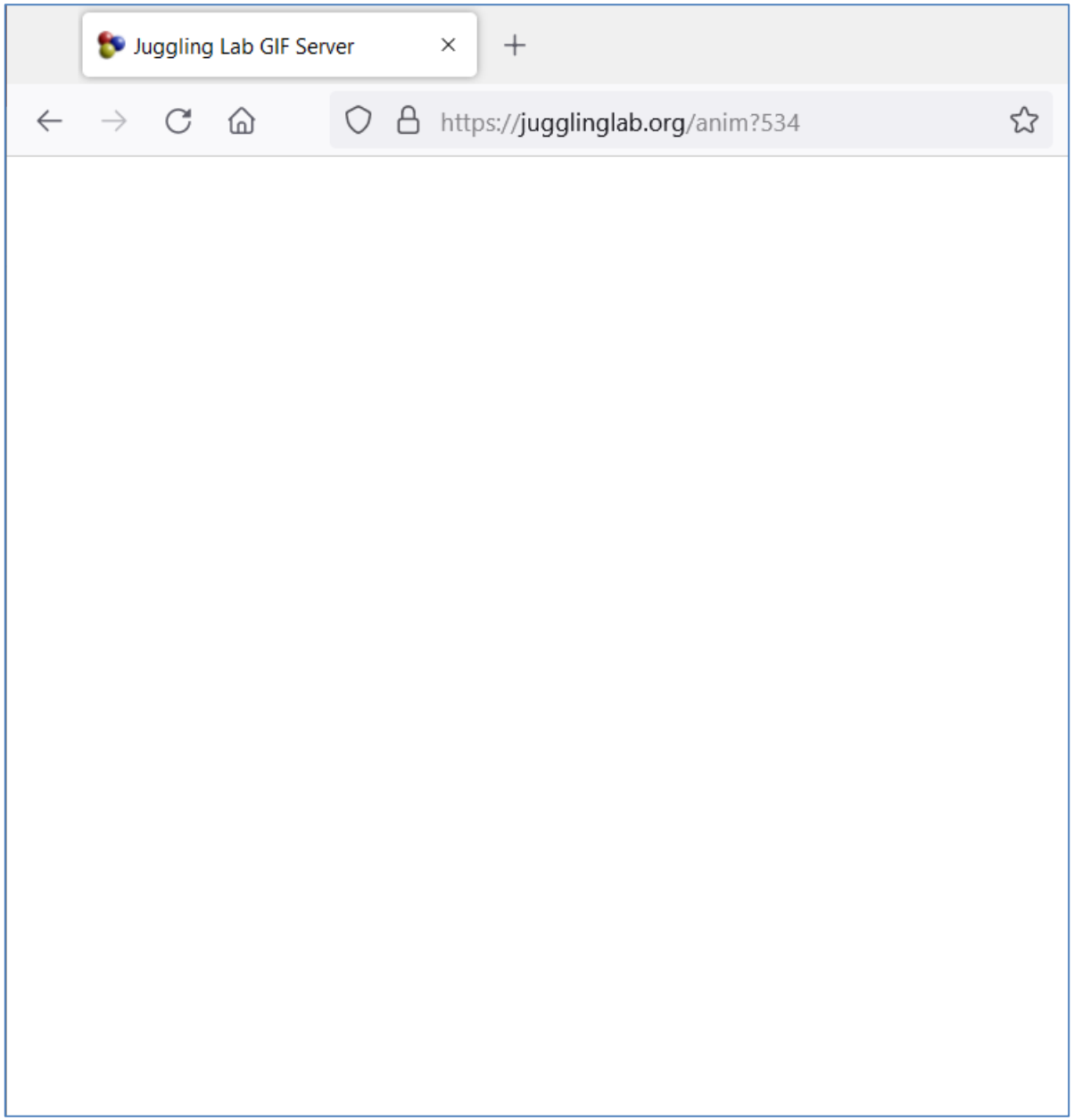
# Shannon's Juggling Theorem

$$\frac{F + D}{V + D} = \frac{B}{H}$$

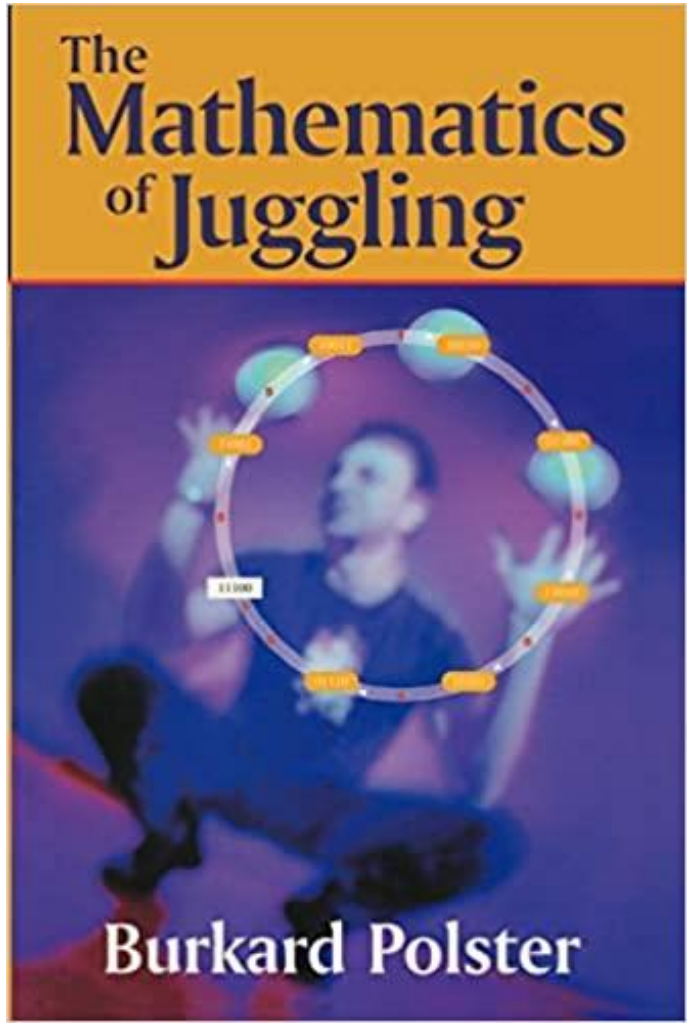
- F = flight time
- D = dwell time
- V = vacant time
- B = # bolde
- H = # hender

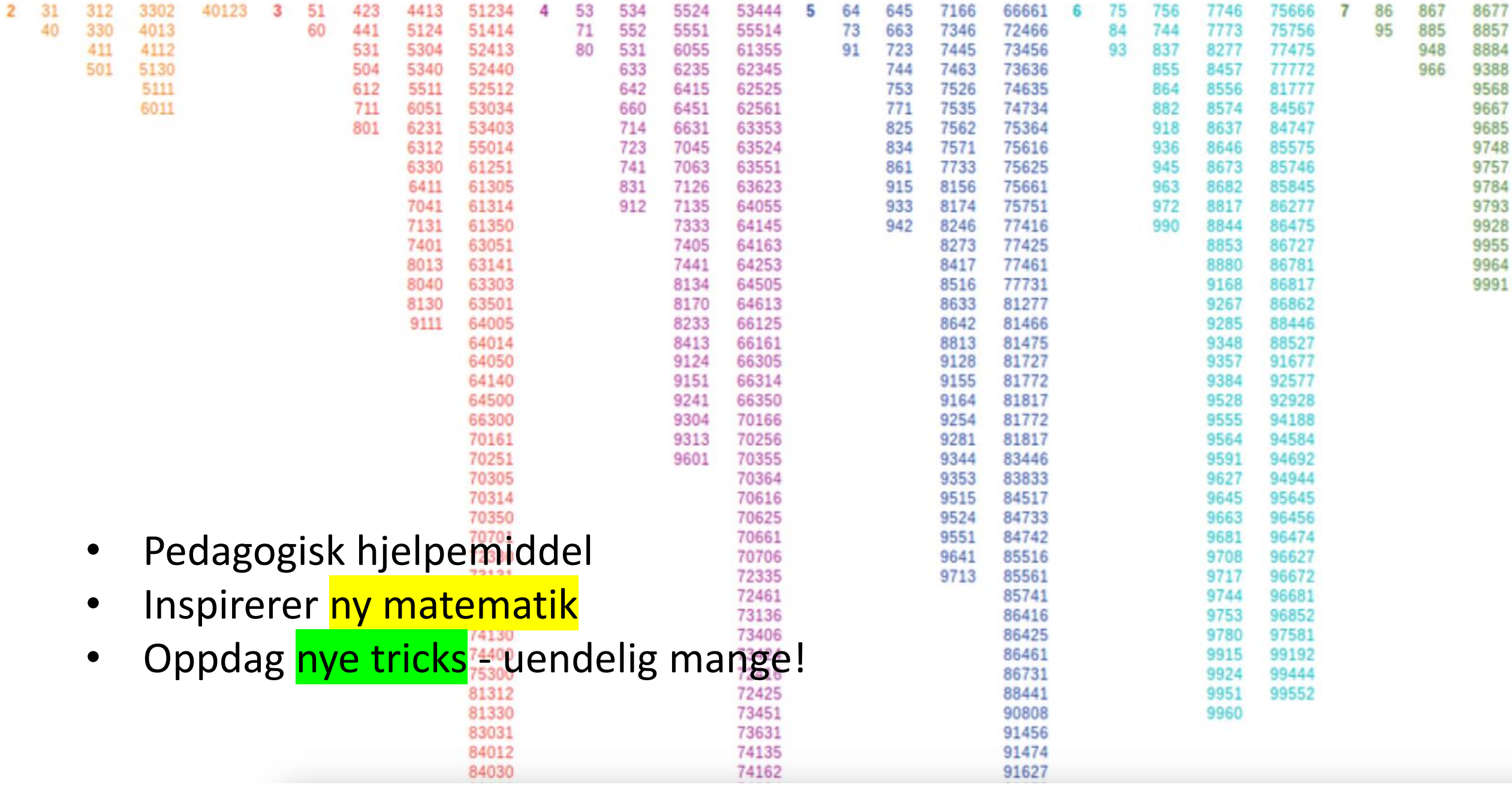
**Bevis:** Tiden av 1 omløp er

$$\underbrace{(F + D)H}_{\text{fra perspektivet til en ball}} = \underbrace{(V + D)B}_{\text{fra perspektivet til en hånd}}$$


Juggling Lab GIF Server
https://jugglinglab.org/anim?534

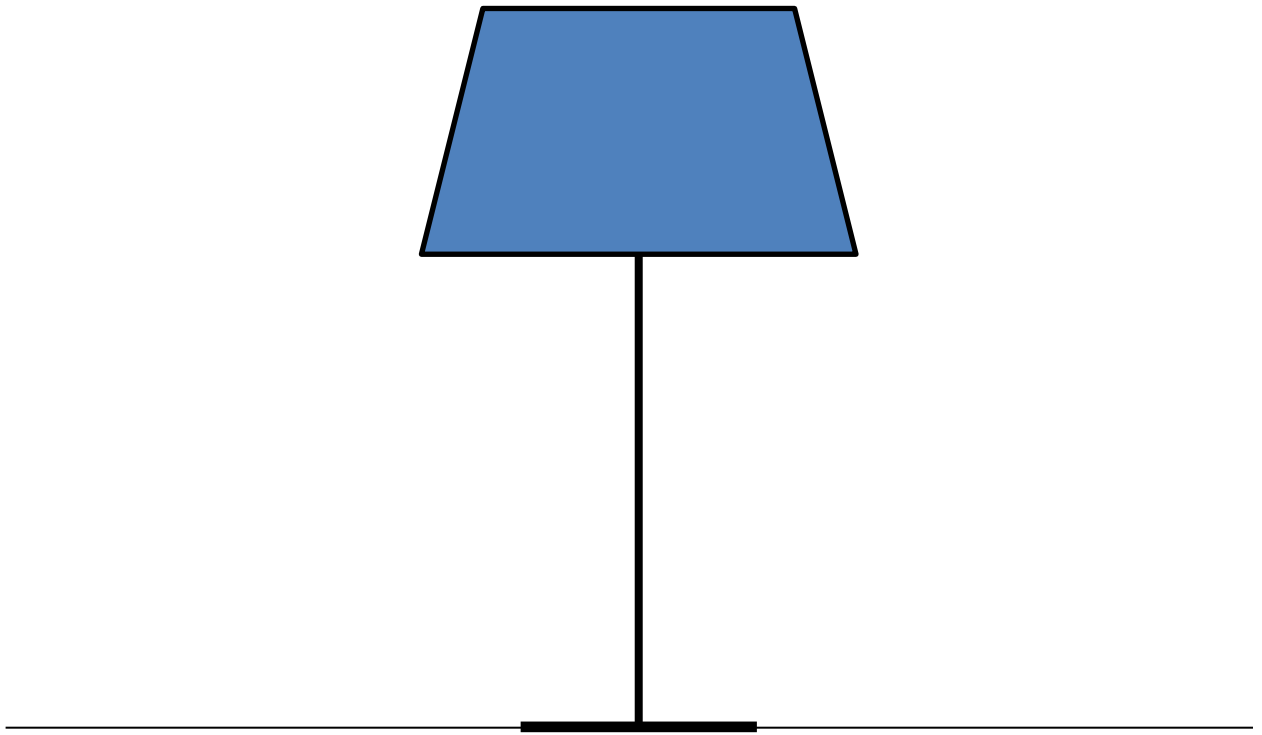

- Pedagogisk hjelpemiddel
- Inspirerer ny matematik
- Oppdag nye tricks - uendelig mange!



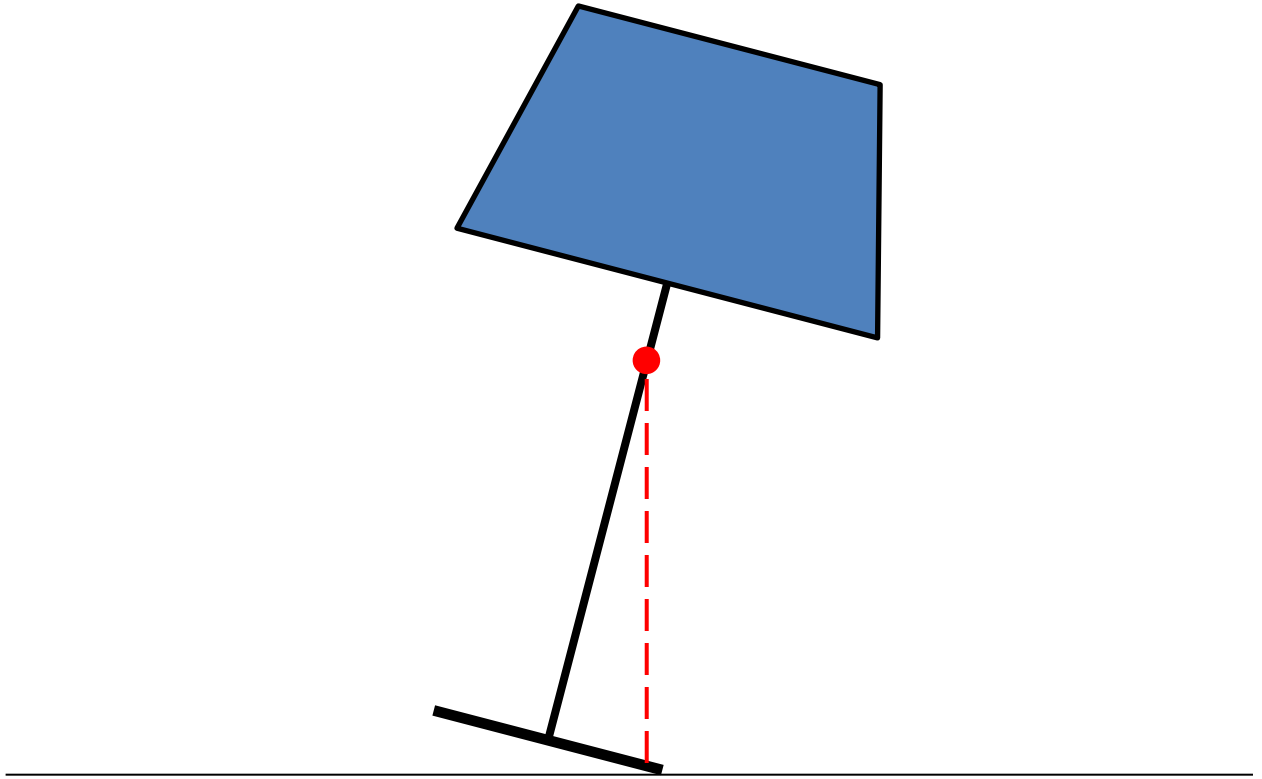


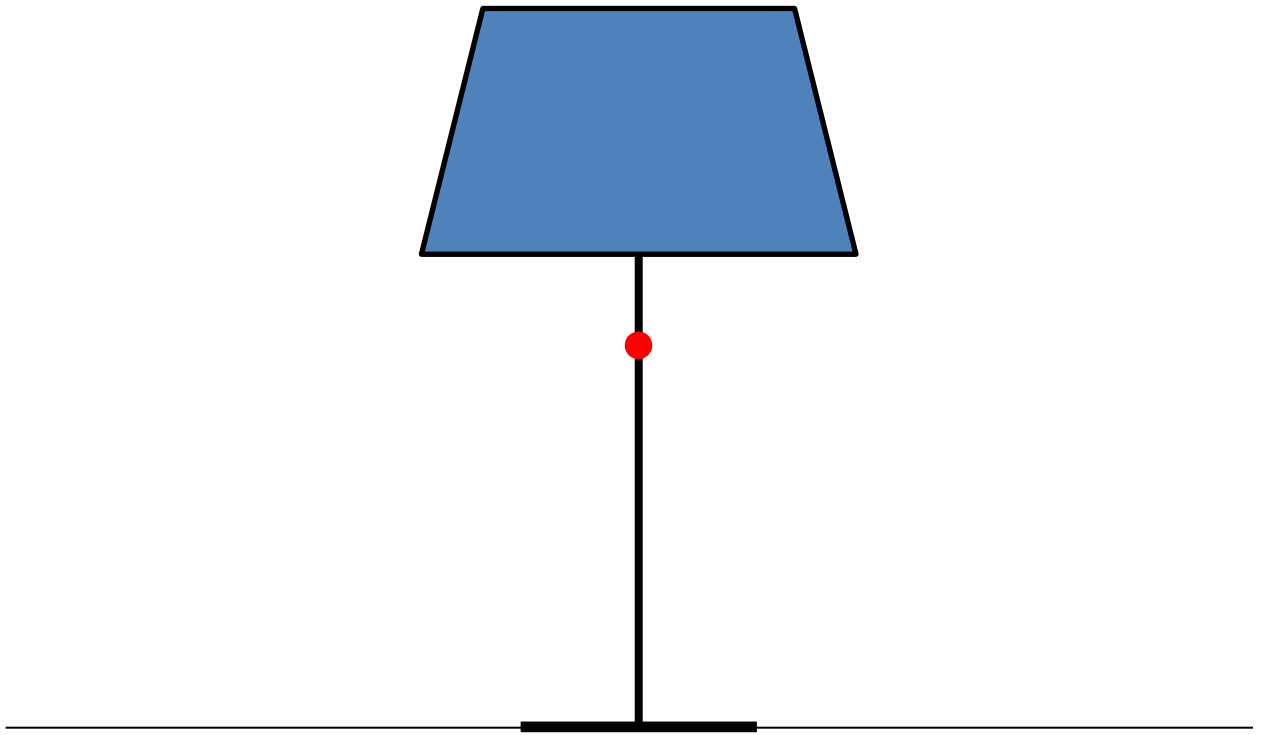

- Pedagogisk hjelpemiddel
- Inspirerer ny matematik
- Oppdag nye tricks - uendelig mange!

# Del 2: BALANCE



# Falder den?





Stabil balance

Labil balance

# Tips til å balancere

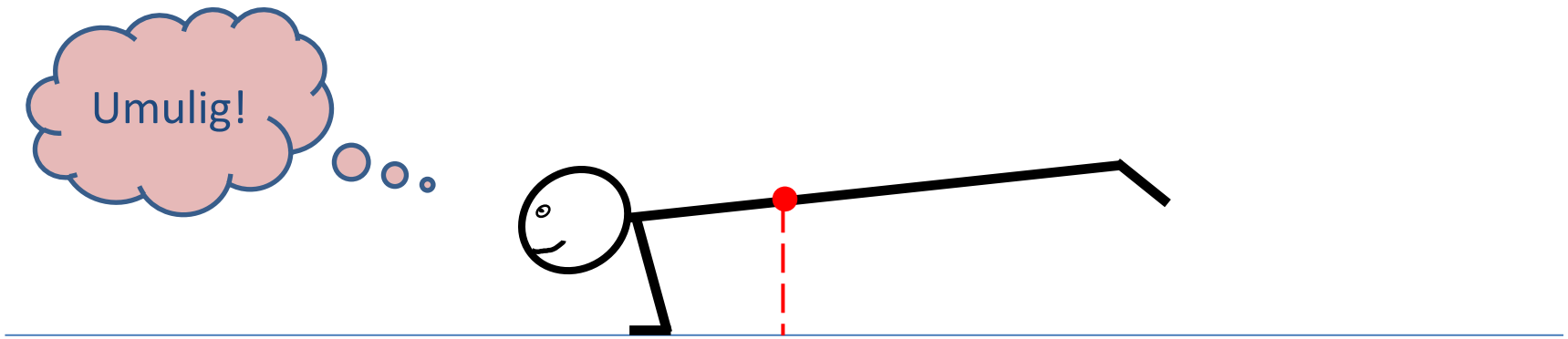
- Kig på tyngdepunktet - ikke toppen
- Lange ting bedre enn korte
- Nesen/panden bedre enn hånden
- Luftmodstand er godt (men ikke vind!)


EL
MAGNUS

# Fysik-tips til å lære håndstand

- Hold tyngdepunktet stille!
  - Ikke gelé
  - Ikke banan
- Lettere å gå enn å stå
  - (Men ikke lige så imponerende)
- Bruk for både **styrke** og **balance**

Anatoly Zalievsky




**Idé:** Sett noe tungt på hodet!