Down loadable TWM related files, visit my website:

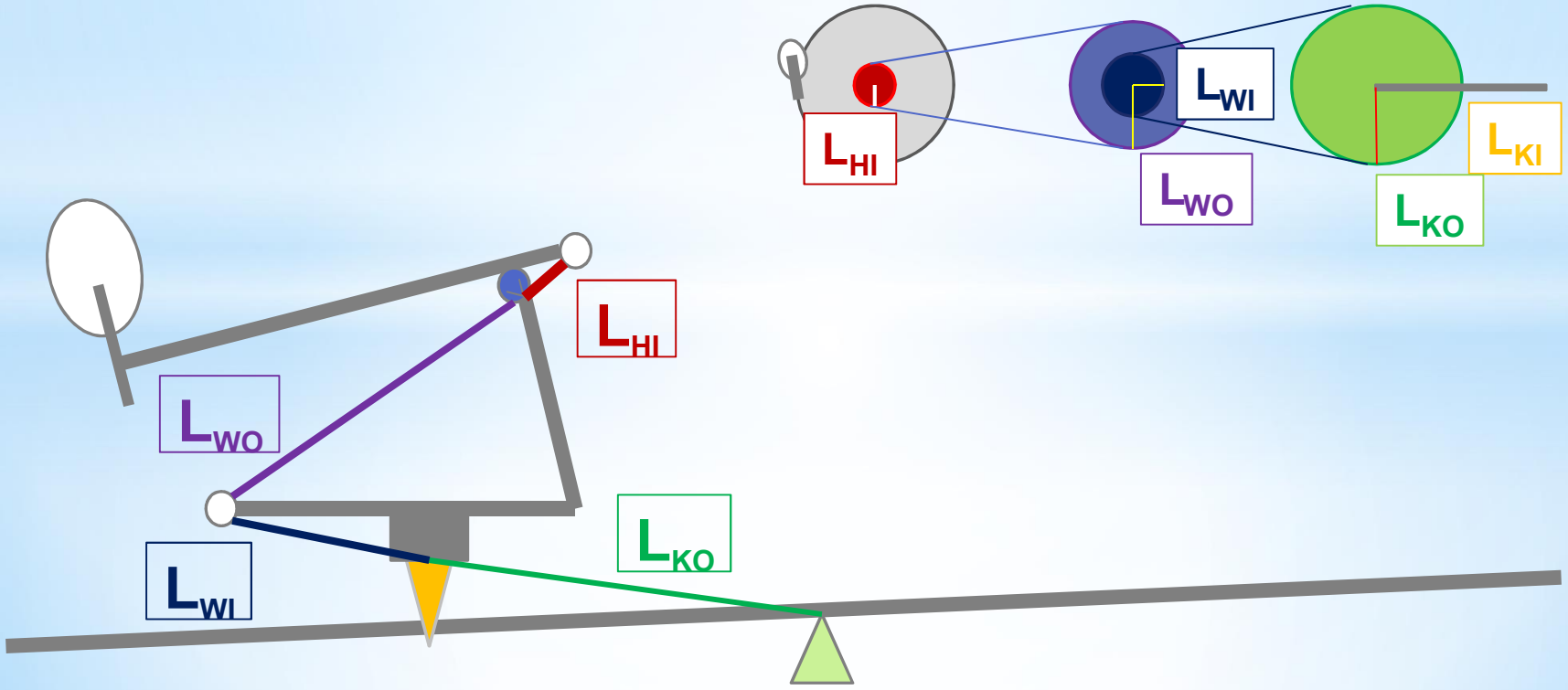
https://www.ynpianotuning.com/downloadable-files

You tube channel, starts August 2019:

https://www.youtube.com/watch?v=QB5FiefumqU

Please subscribe if you like more.

Understanding inertial effect
in grand action



Yuji Nakamura, ARPT, New Zealand

Traditional "Touch Weight"

is indicated by combination of
Down weight and Up weight

Example: DW = 52 g & UW = 26 g

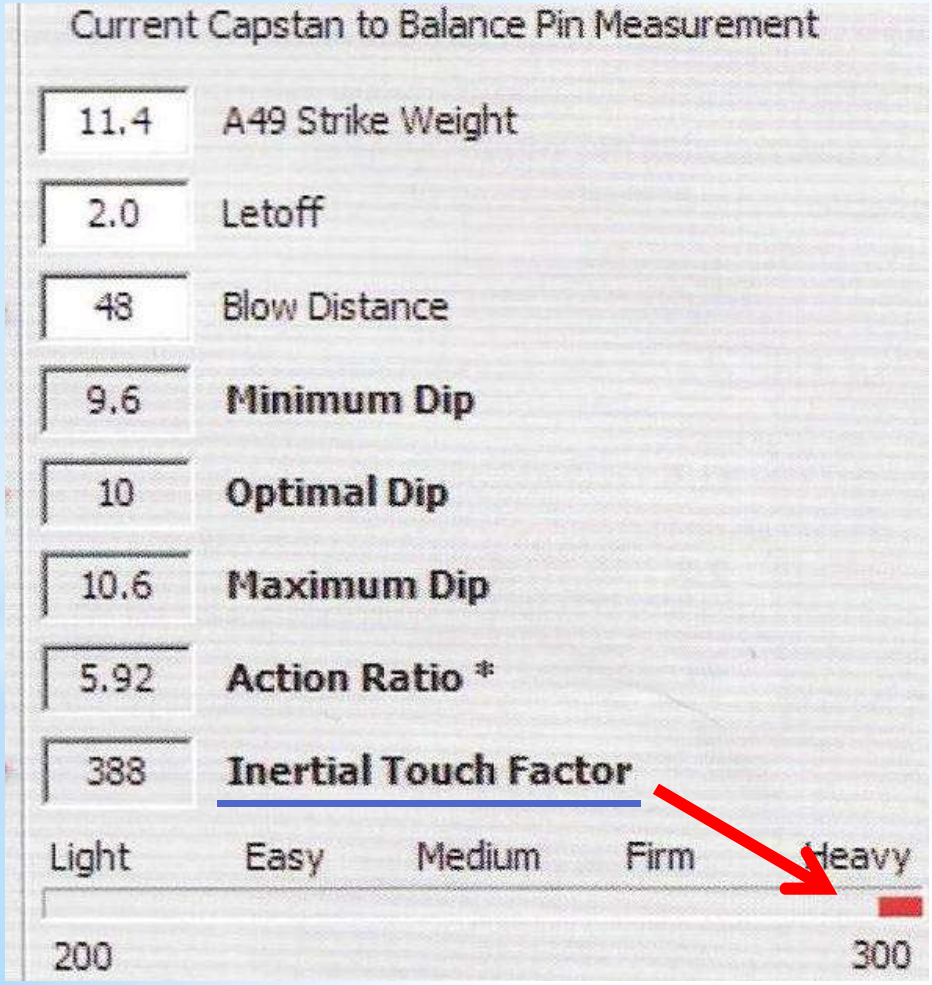
Dynamic Touchweight

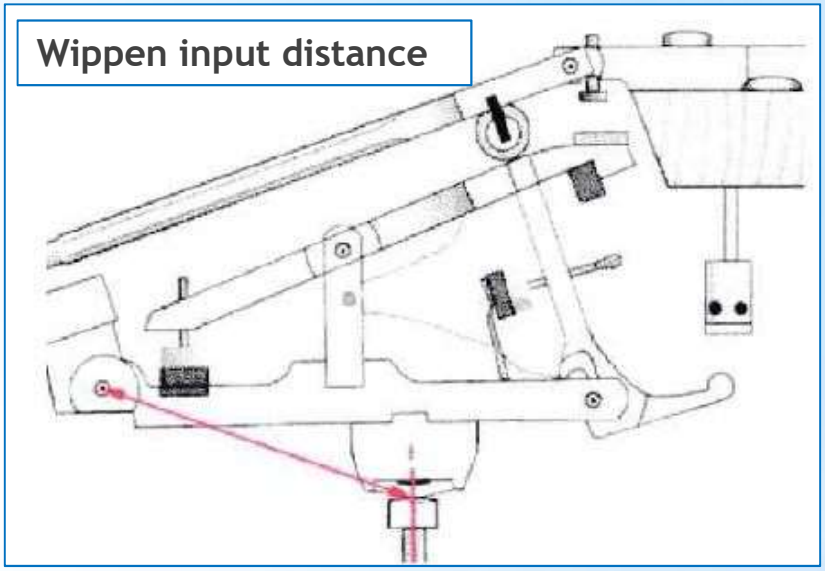
Touch weight felt while playing

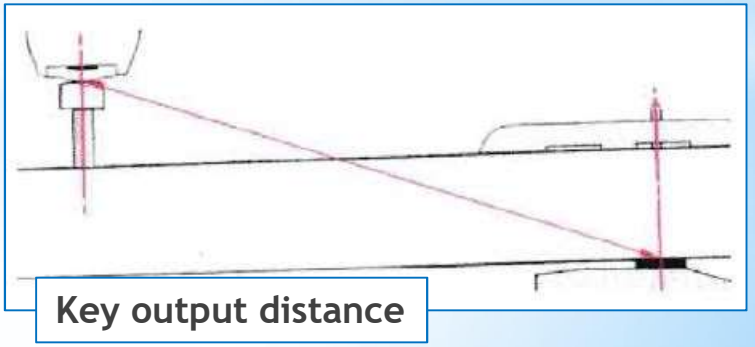
“Measurement of DW & UW doesn’t stand actual playing as they were measured by movement at less than pp playing”

Approach to inertial effect in the piano action

by Darren Fandrich & John Rhodes







Approach to adjust inertial effect in the piano action

“Touch Weight Management”

- Manage two indexes together;
  - static “Balance Weight” and
  - kinetic resistance “Moment of Inertia”
- Understand theory to manage touchweight

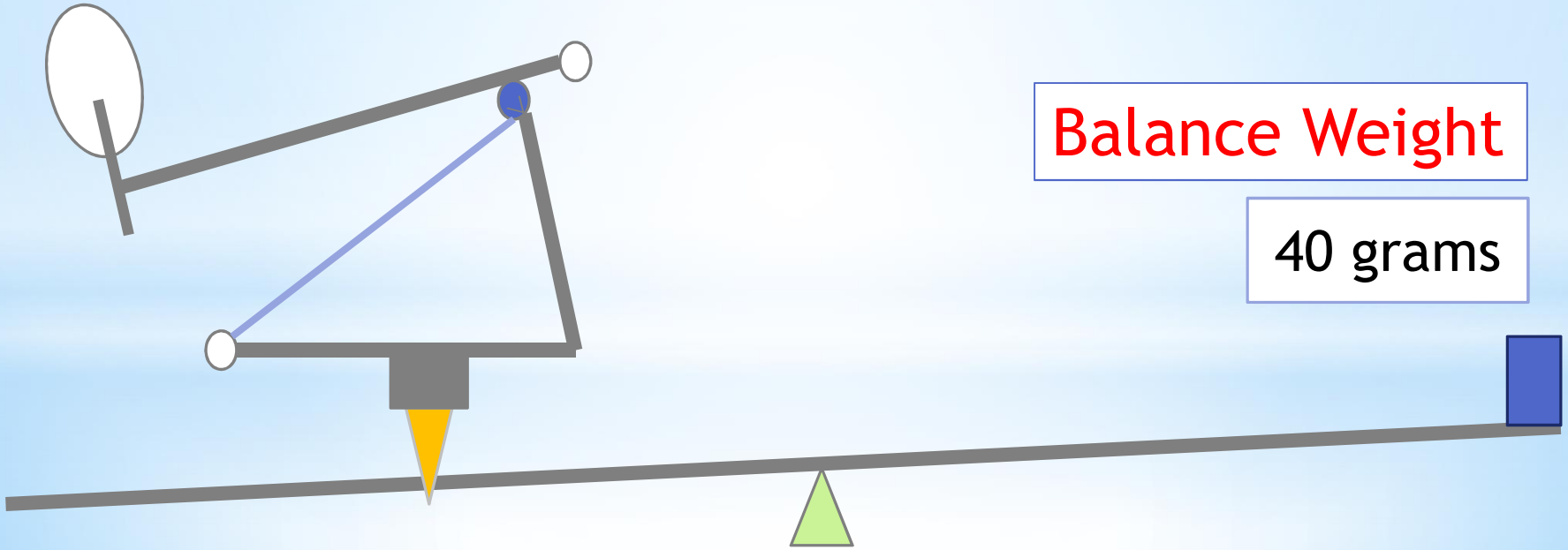
Components of Touch Weight

- Balance weight
- Friction weight
- Additional torque

  (= Moment of Inertia x angular acceleration)

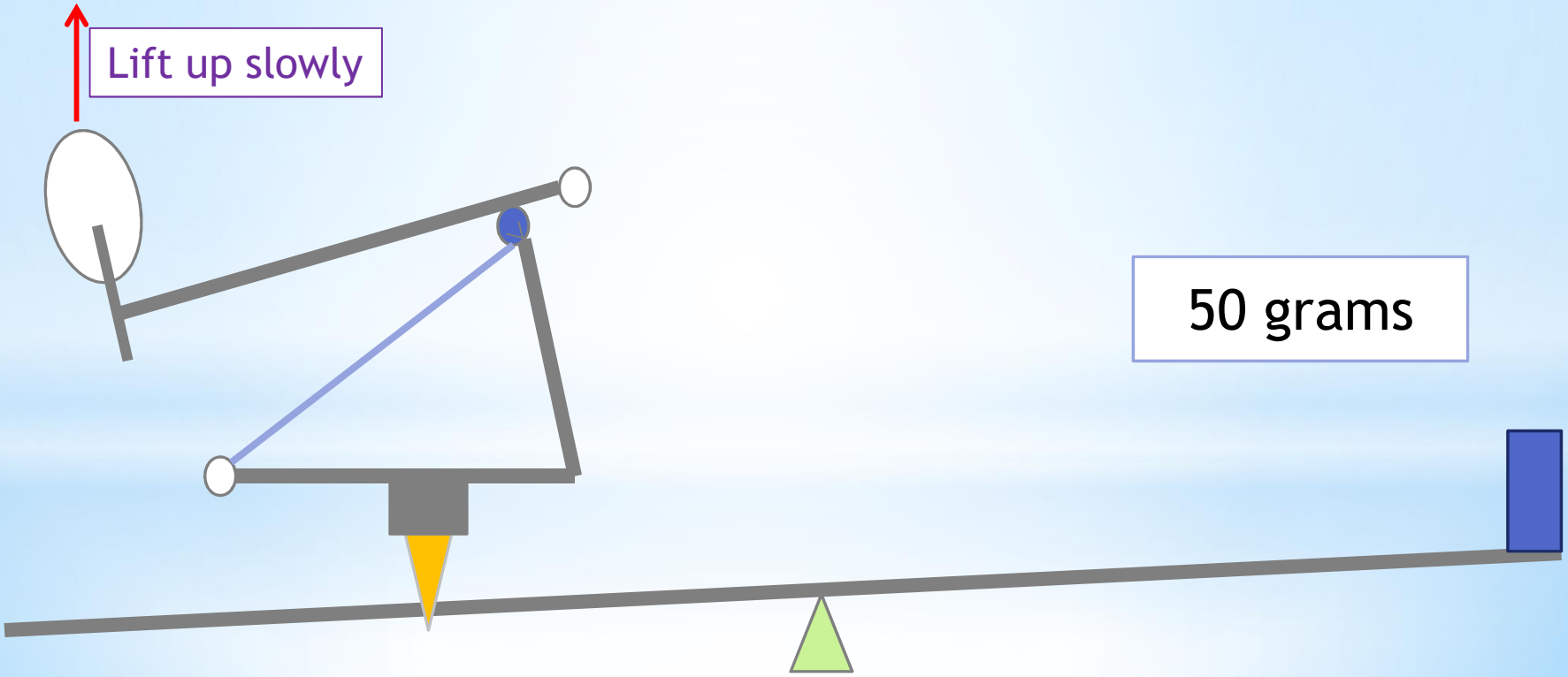
Balance Weight

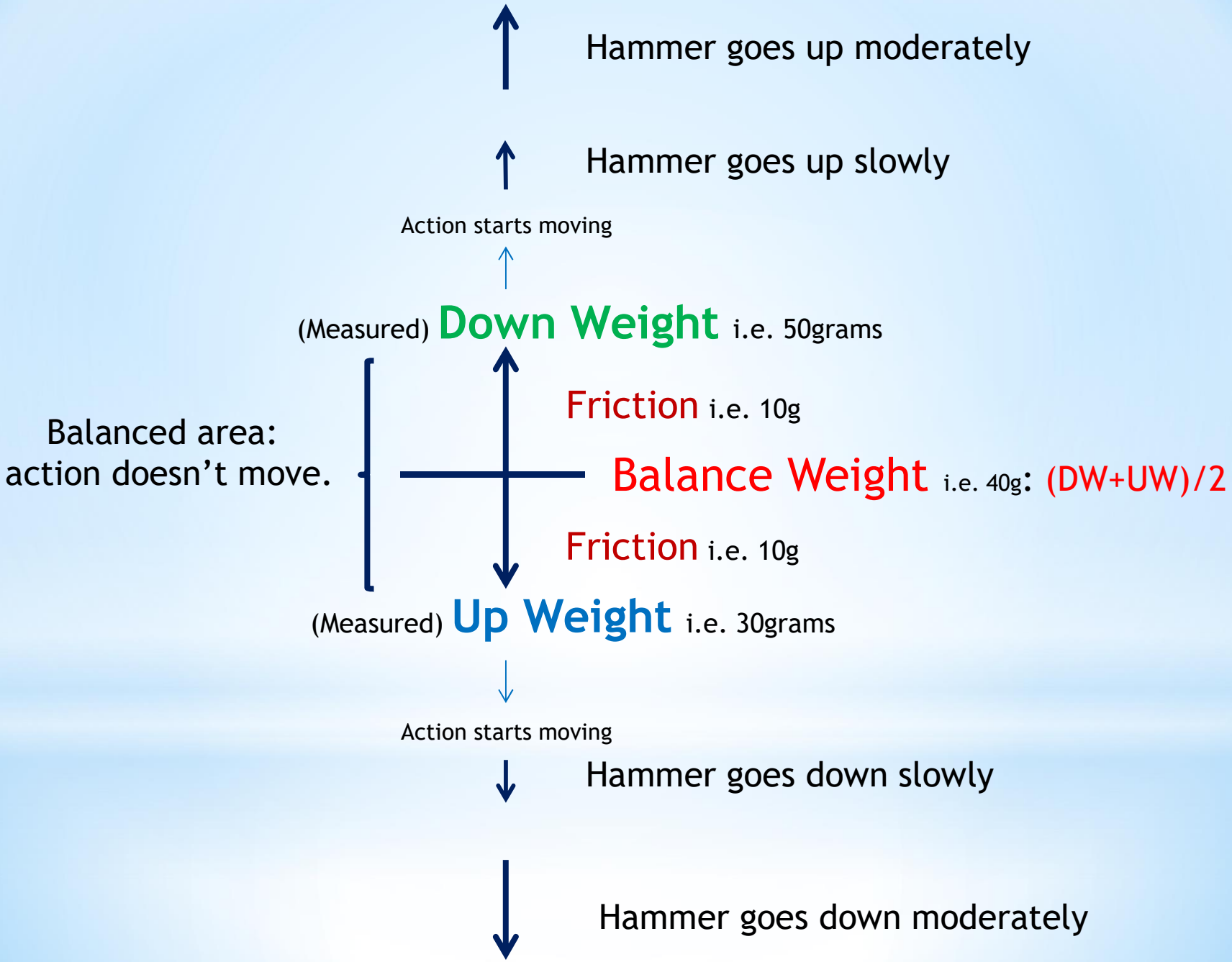
Action balances with certain weight



Down Weight

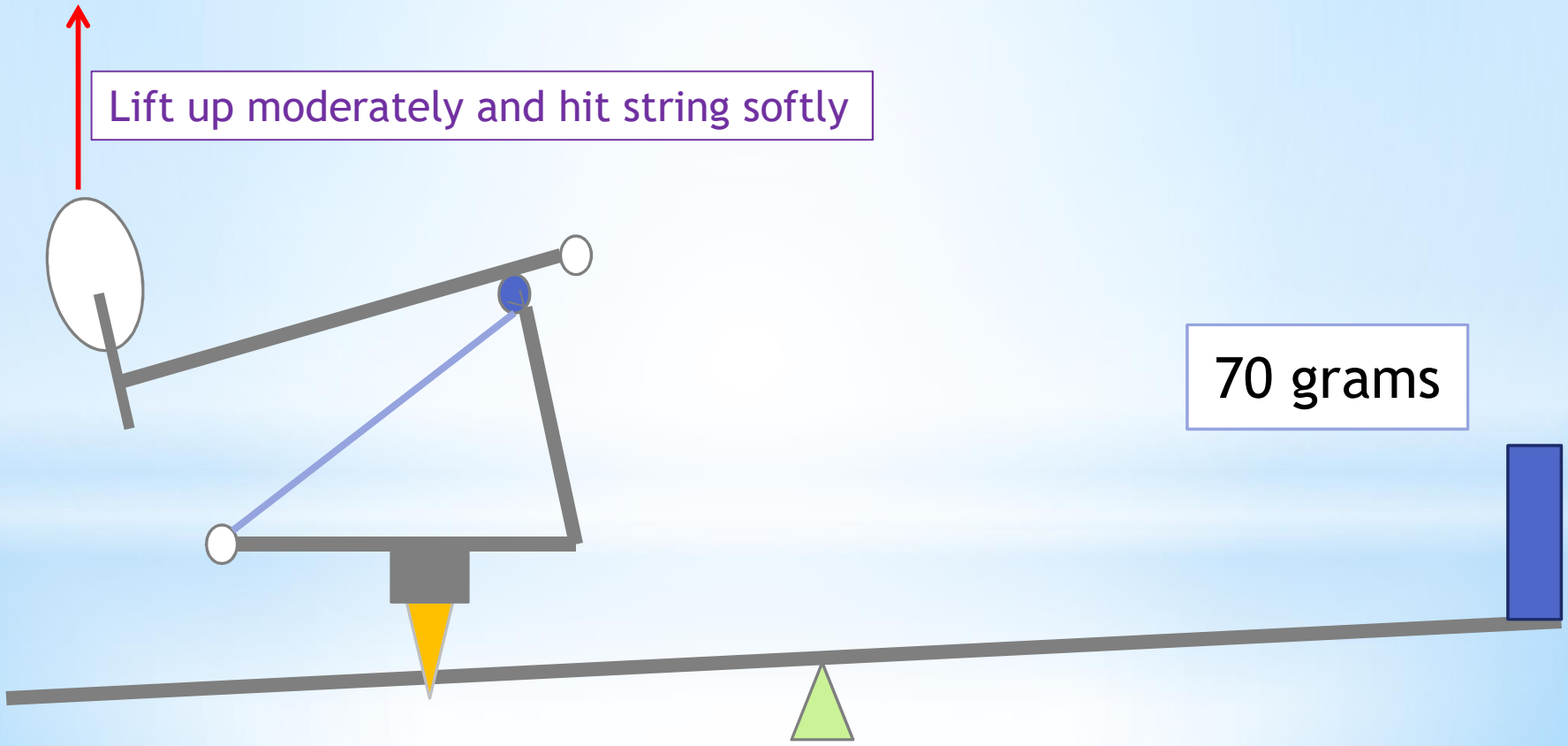
Balance Weight (40g) + Friction (10g)




Hammer goes up moderately
Hammer goes up slowly
Action starts moving
(Measured) Down Weight i.e. 50grams
Friction i.e. 10g
Balanced area:
action doesn't move.
Balance Weight i.e. 40g: (DW+UW)/2
Friction i.e. 10g
(Measured) Up Weight i.e. 30grams
Action starts moving
Hammer goes down slowly
Hammer goes down moderately

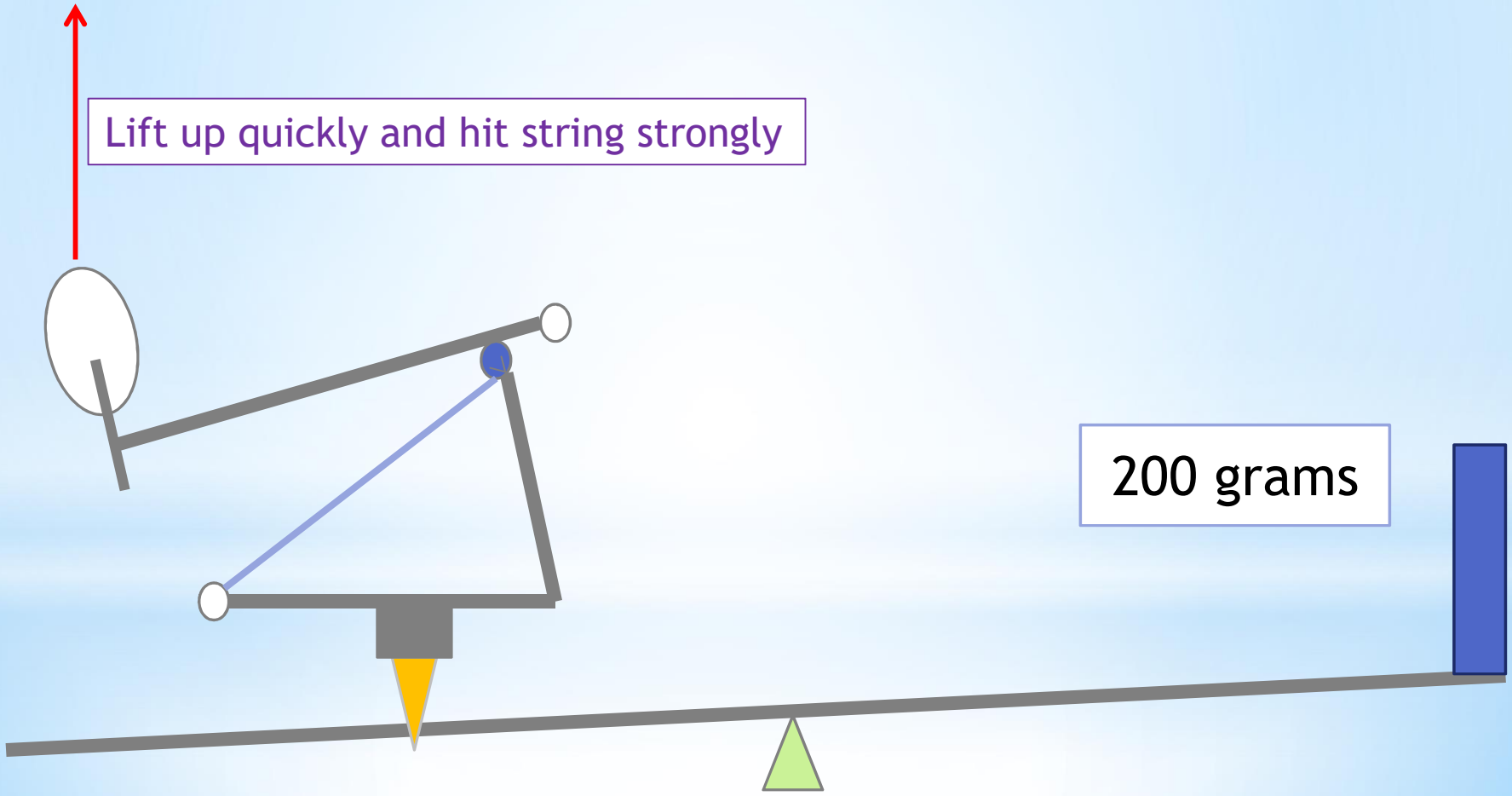
Strike string lightly

BW (40g) + F (10g) + Additional torque (20g)



Strike string strongly

BW (40g) + F (10g) + More Additional torque (150g)



Example of heavy touch (1)

1, Heavy BW , Normal Friction , Normal MoI

BW = 60 g (DW 70 g & UW 50 g), F = 10 g

At BW (40g) & F (10g): Move moderately with **20g of additional torque**

At BW(60g) & F (10g): Move slowly as if Down Weight measurement

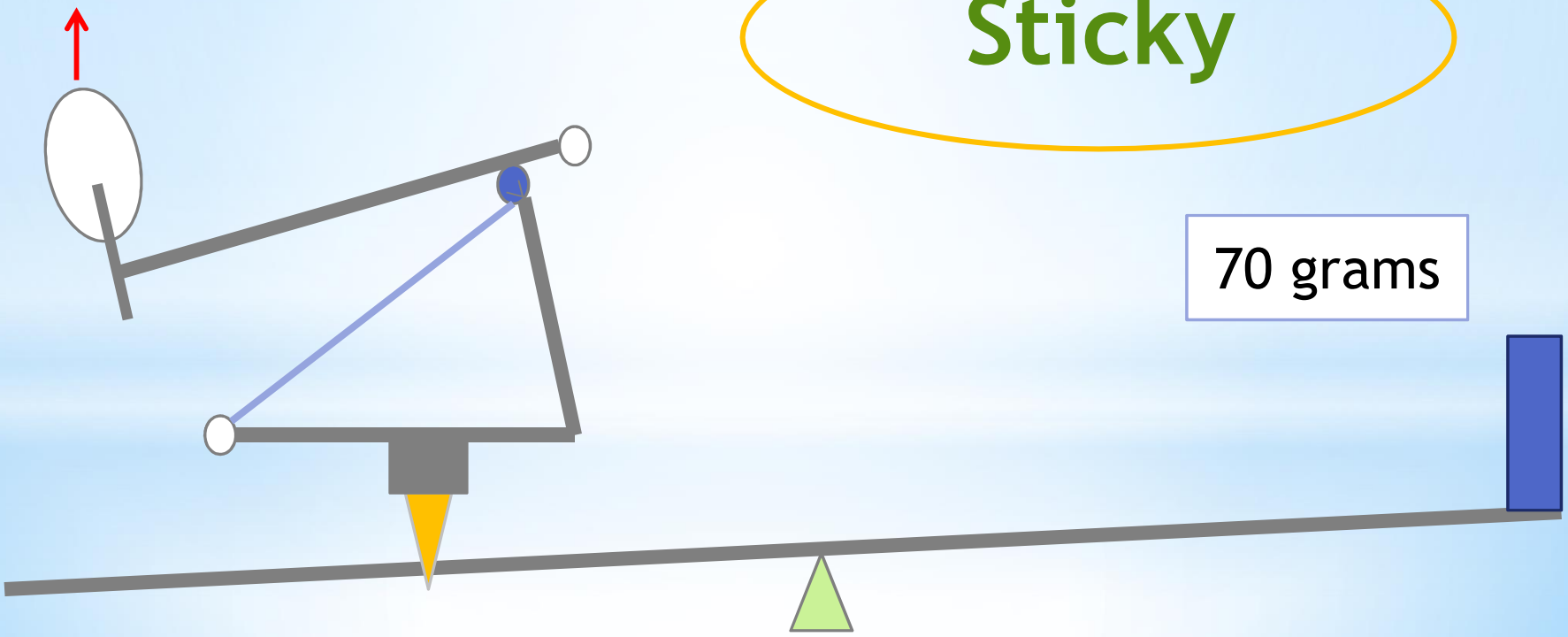
Example of heavy touch (2)

2, Moderate BW , Big Friction , Normal MoI

BW = 40 g (DW 70 g & UW 10 g, F = 30 g

At BW (40g) & F (10g): Move moderately with **20g of additional torque**

At BW(40g) & F (30g): Move slowly as if Down Weight measurement



Example of heavy touch (3)

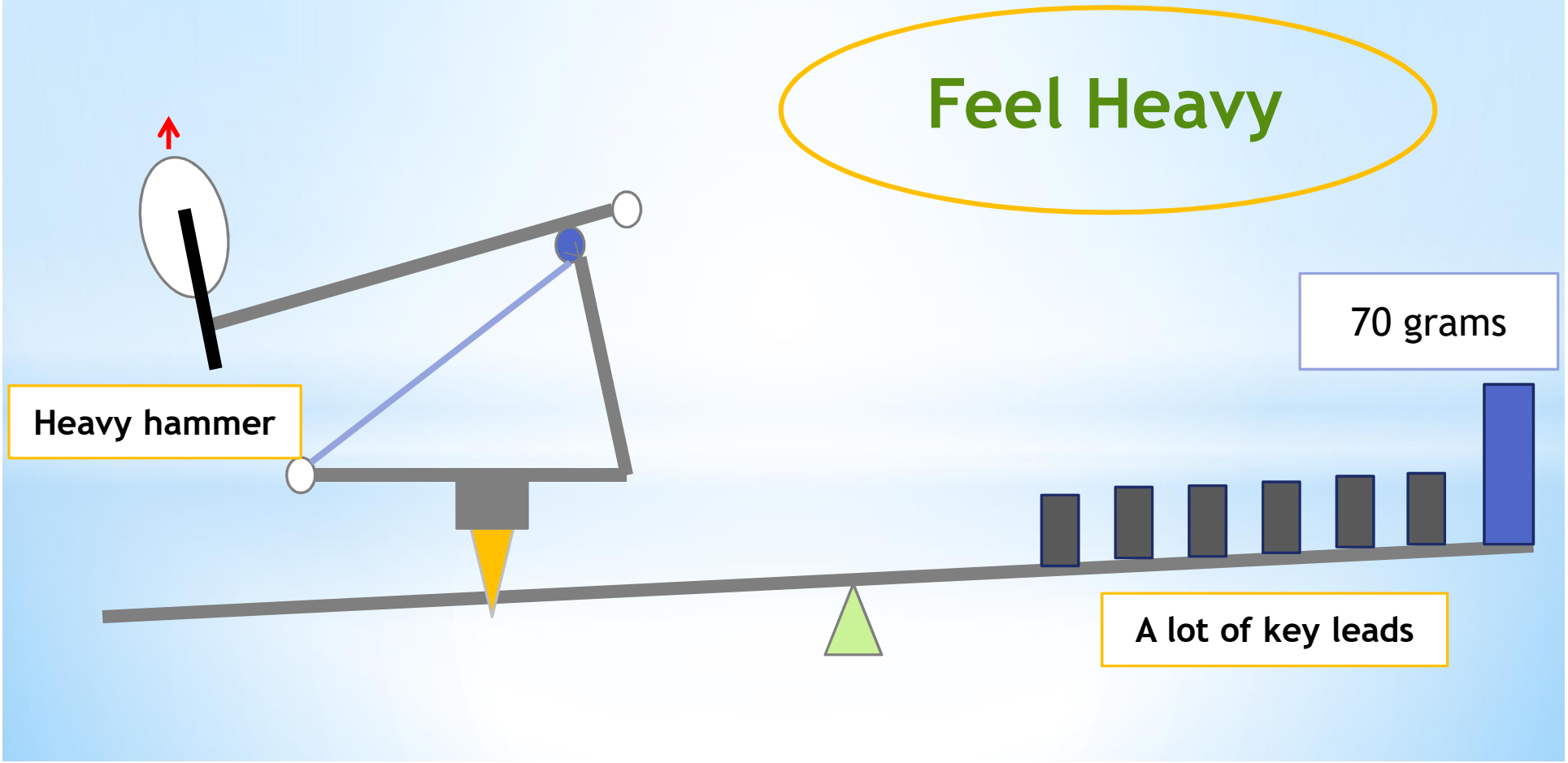
3, Moderate BW , Normal Friction , Big MoI

BW = 40 g (DW 50 g & UW 30 g), F = 10 g

You may observe fat & wide hammers and lots of key leads in this case

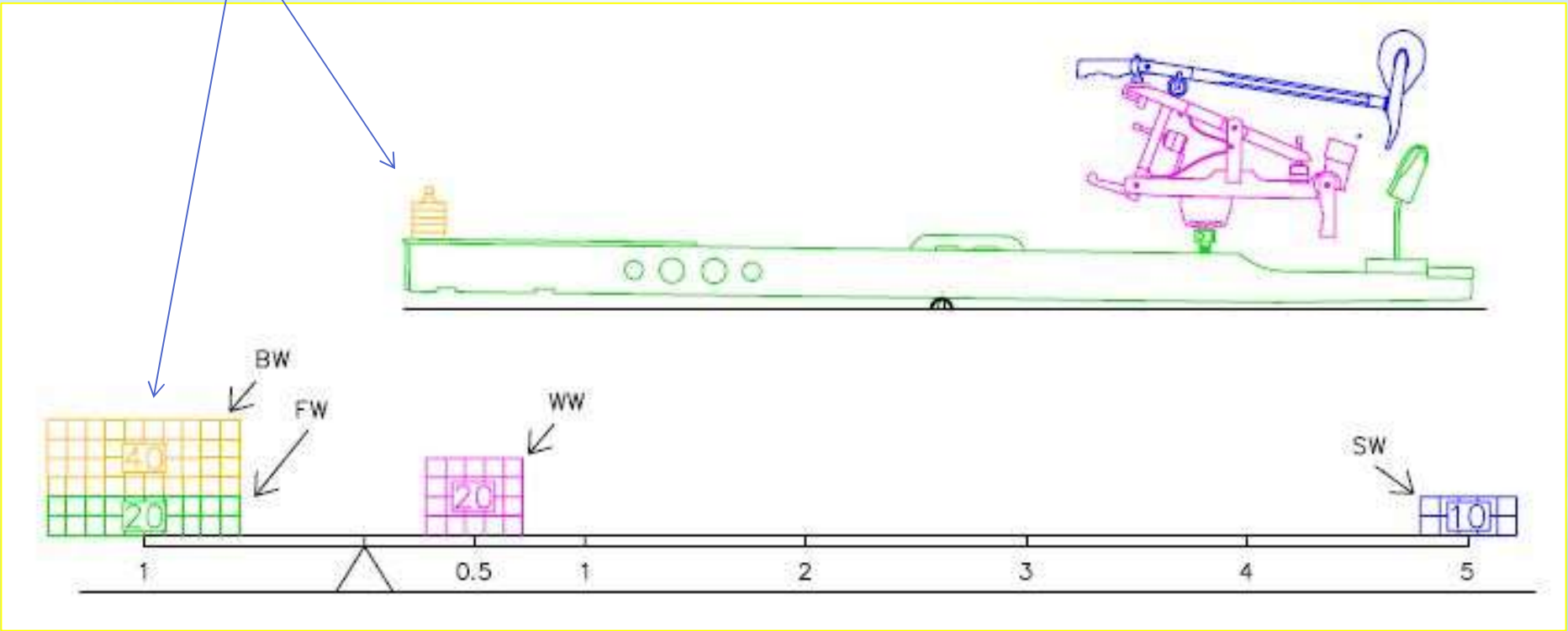
At BW (40g) & F (10g): Move moderately with **20g of additional torque**

At BW(40g) & F (10g): Move slowly with **20g of additional torque**



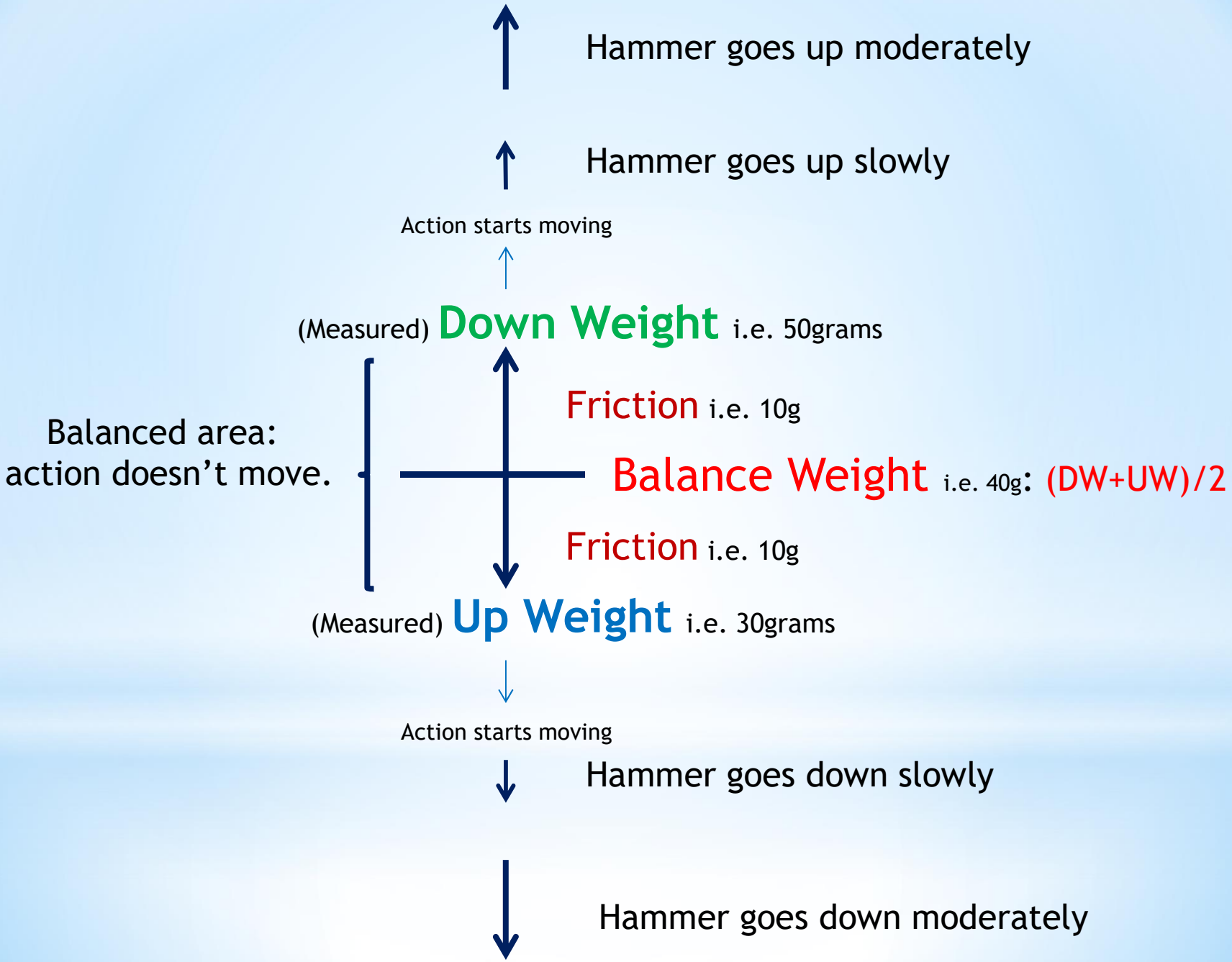
What is “Balance Weight”

BW + FW= WW x KR + HSW x SR

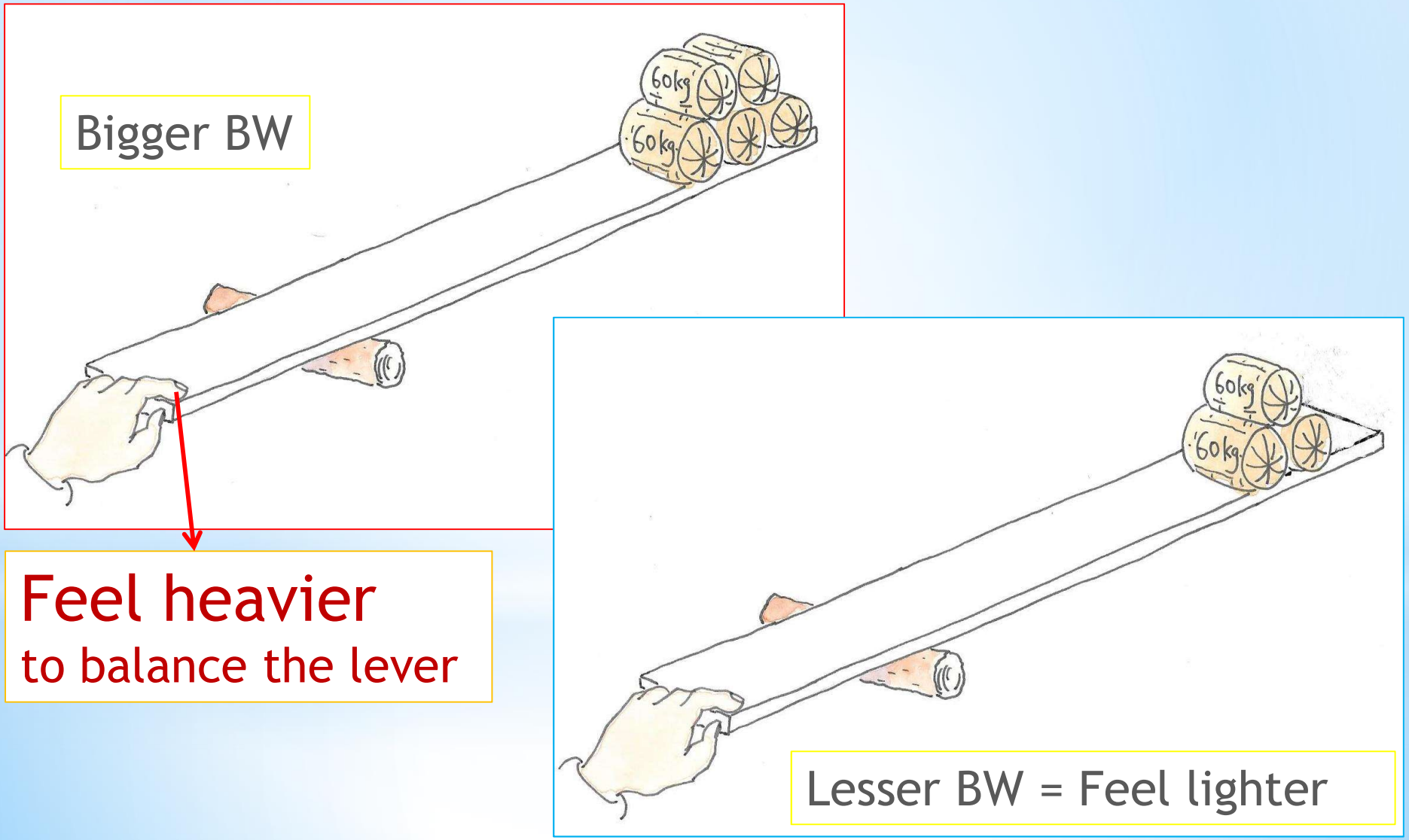


BW = (DW + UW) / 2

Seesaw model by David Stanwood


Hammer goes up moderately
Hammer goes up slowly
Action starts moving
(Measured) Down Weight i.e. 50grams
Friction i.e. 10g
Balanced area:
action doesn't move.
Balance Weight i.e. 40g: (DW+UW)/2
Friction i.e. 10g
(Measured) Up Weight i.e. 30grams
Action starts moving
Hammer goes down slowly
Hammer goes down moderately

Static touchweight: Balance Weight

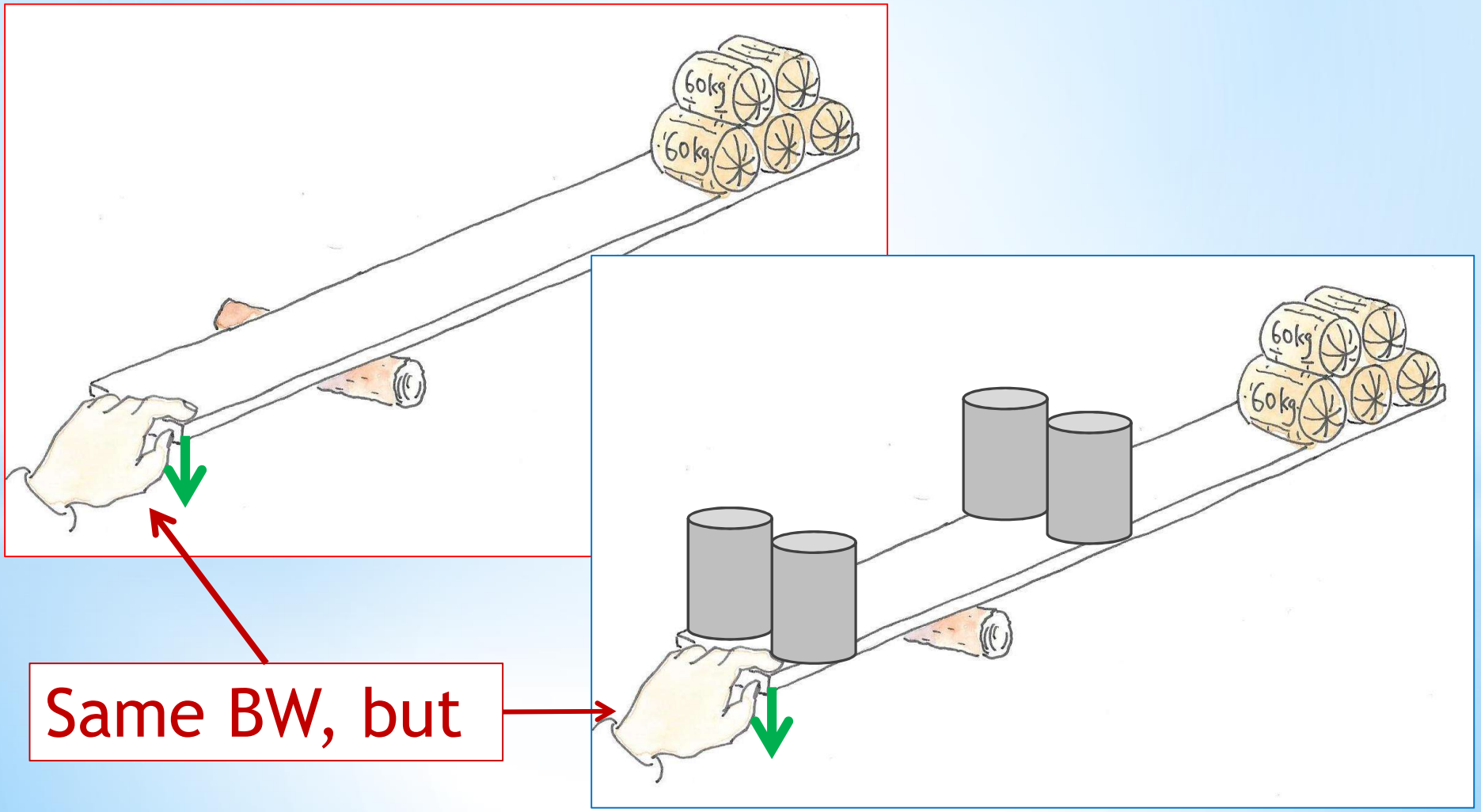


Causes of Friction

- Flange centers
- Key bushing (balance & front)
- Key balance hole
- Capstan – heel connection
- knuckle – jack connection

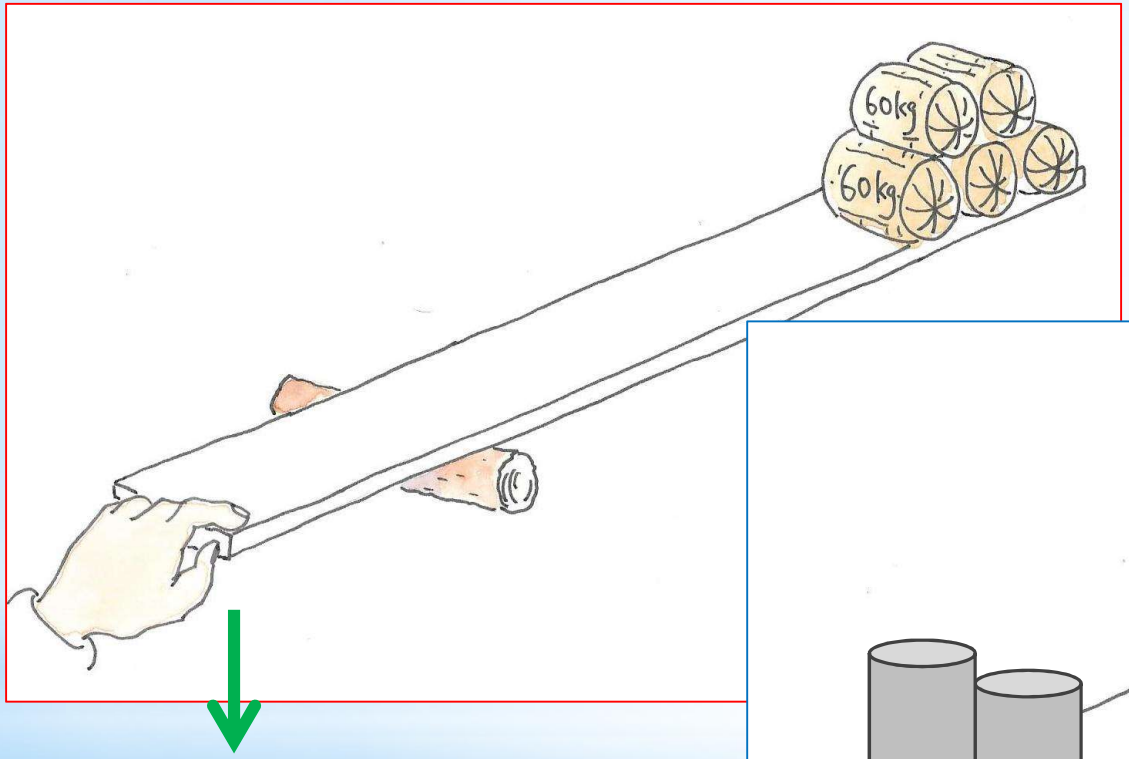
Kinetic Touch Weight

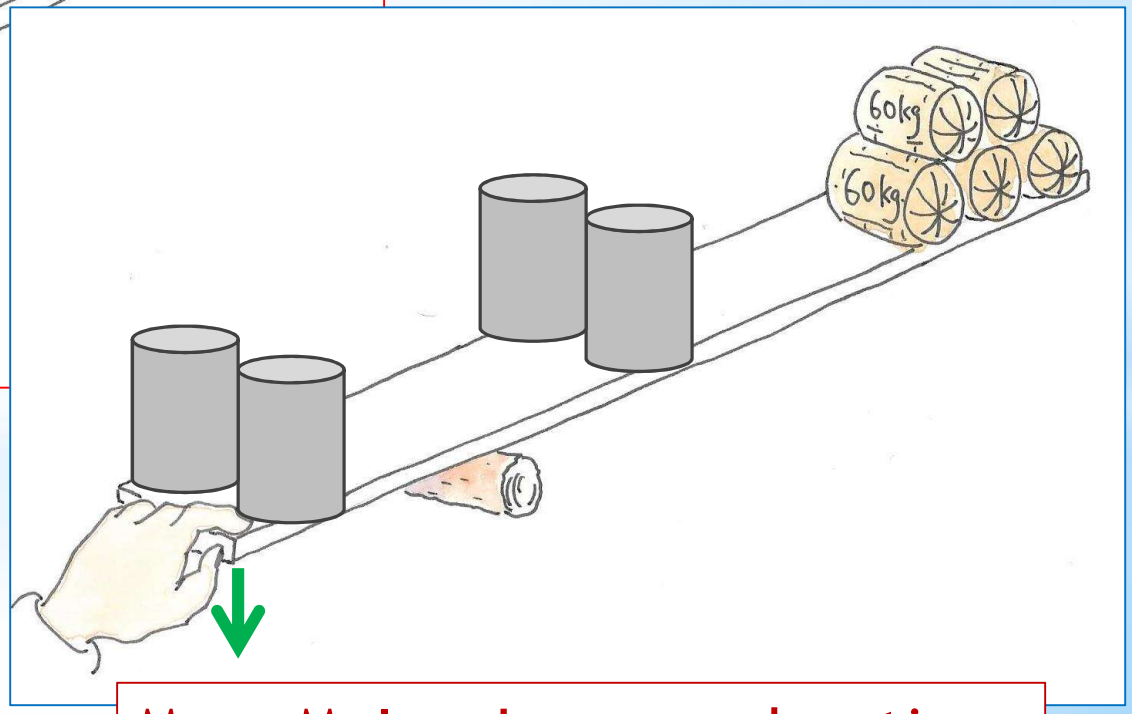
Same BW doesn't mean they feel same "touch weight"



Kinetic Touch Weight

Torque = Moment of Inertia x angular acceleration

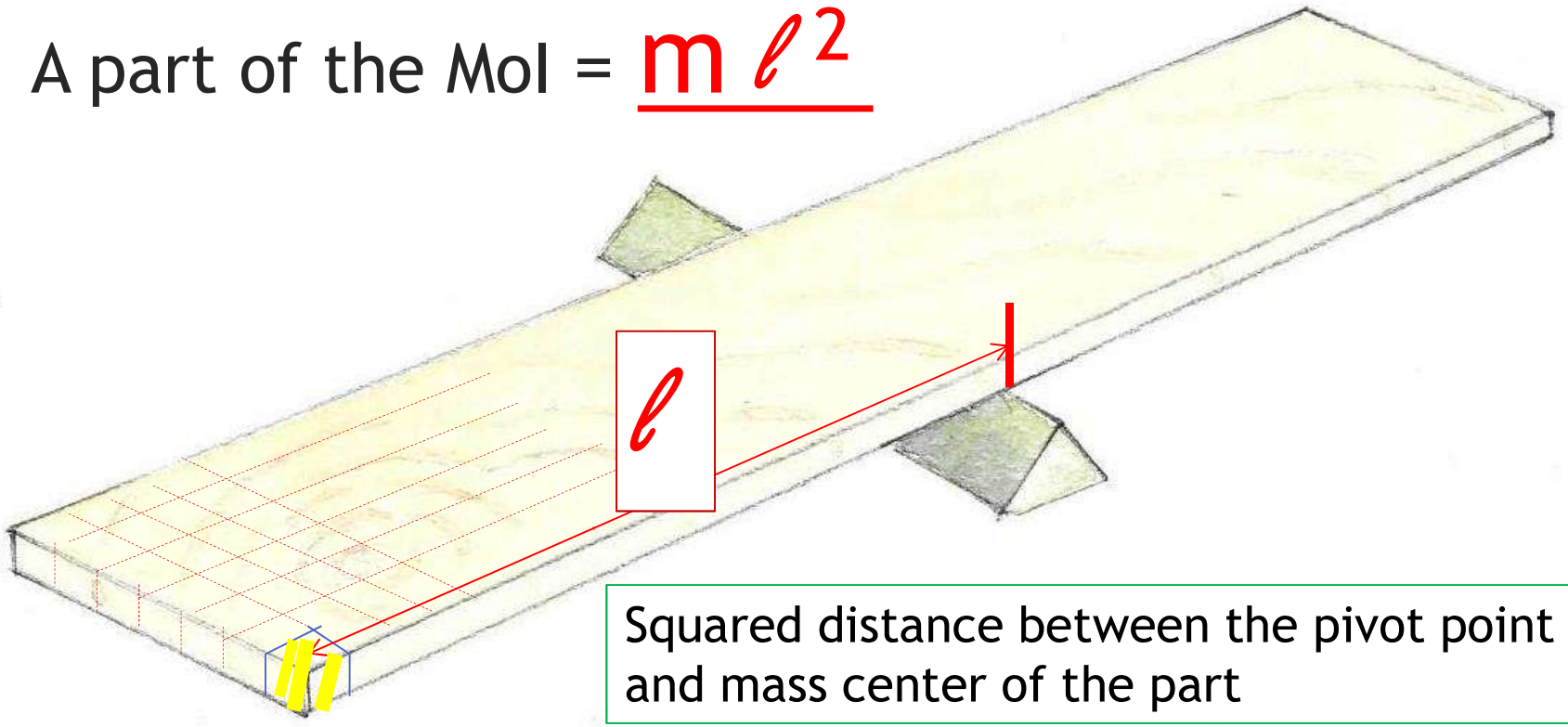




More MoI → Less acceleration

How to calculate MoI

A part of the MoI = $m \ell^2$



Squared distance between the pivot point and mass center of the part

m: Mass of a part

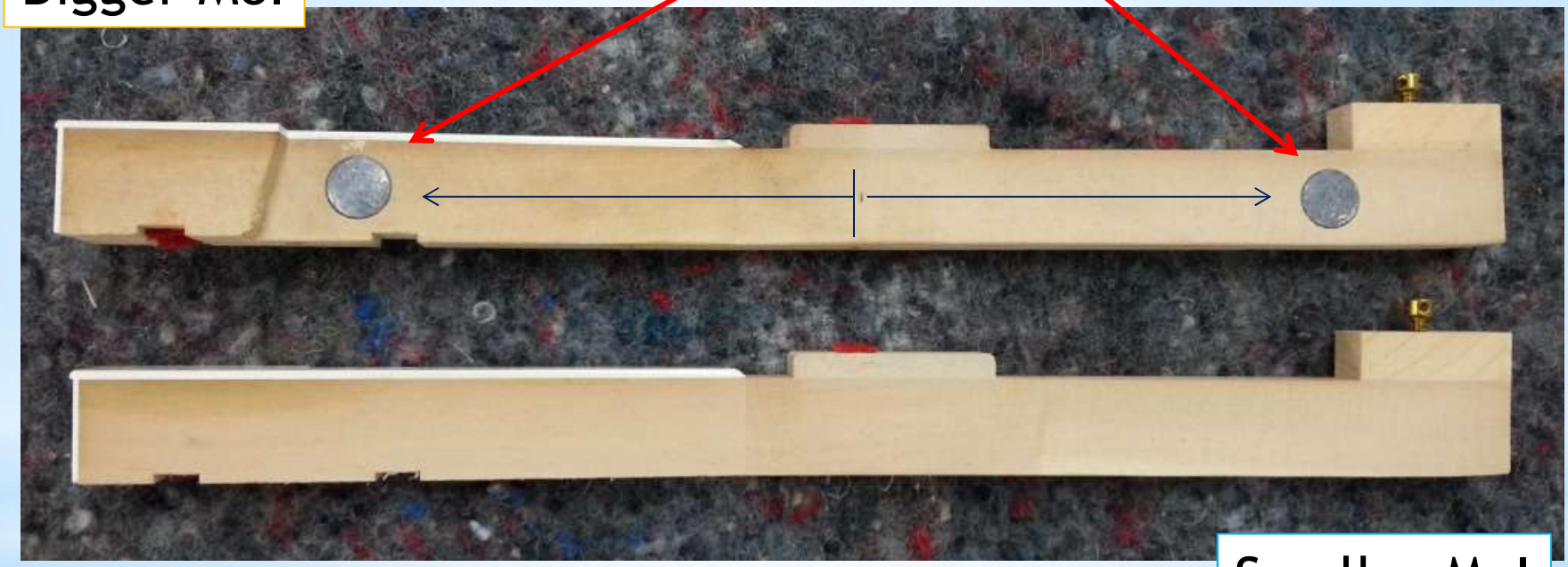
MoI of keys


Back check at far end
Longer key stick
Bigger MoI
More key leads
Smaller MoI

Compare two keys with same length

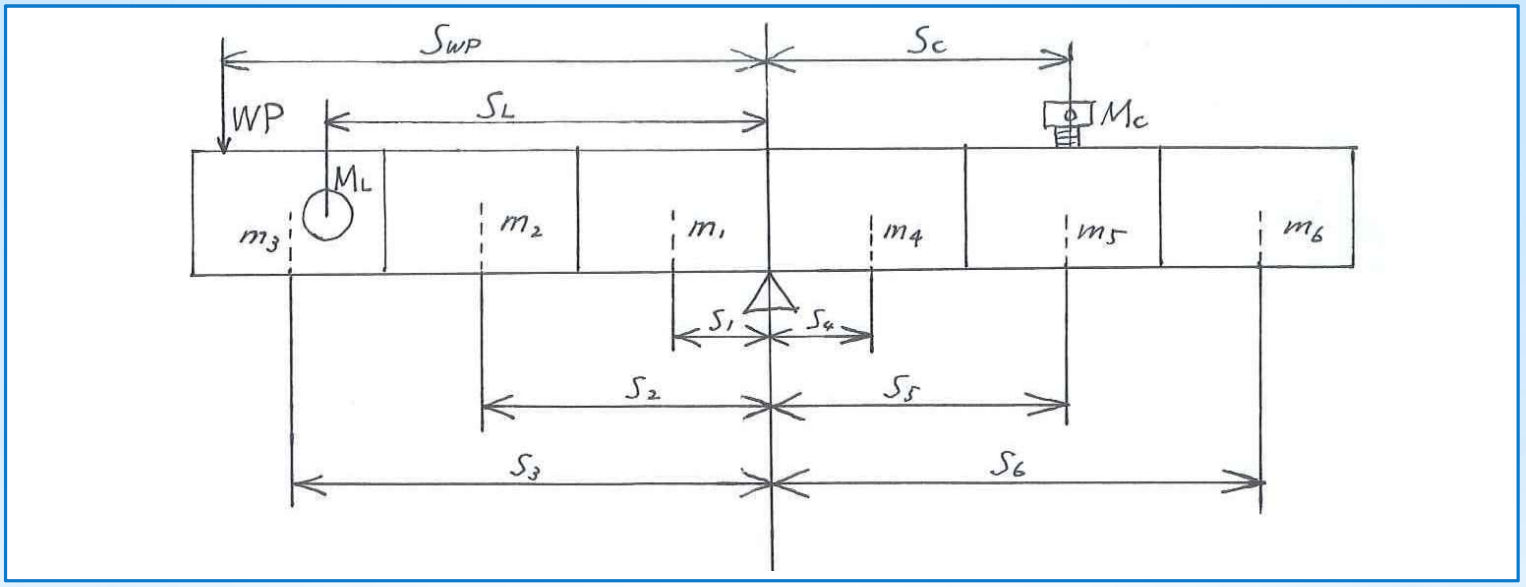
More mass in the key

Bigger MoI



Smaller MoI

Calculating MoI of key model



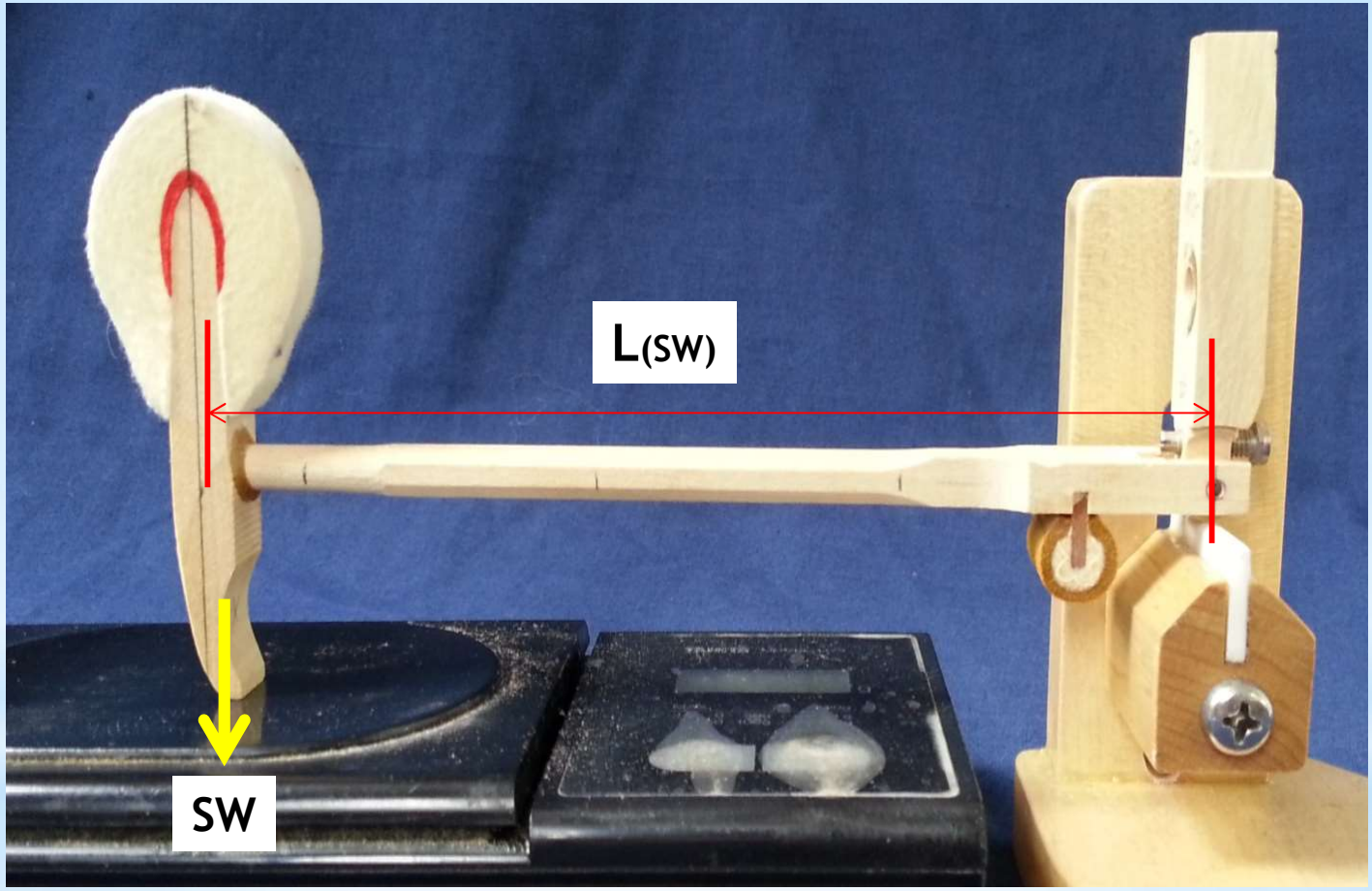
$$MoI_{(key)} = m_1(s_1)^2 + m_2(s_2)^2 + m_3(s_3)^2 + m_L(s_L)^2 + m_4(s_4)^2 + m_5(s_5)^2 + m_6(s_6)^2 + m_c(s_c)^2$$

Examples: A0 of a Steinway D: 72,000 gcm^2,

C4 of a Yamaha C3: 31,000 gcm^2,

C4 of a Kawai K3: 6,000 gcm^2

MoI of a hammer



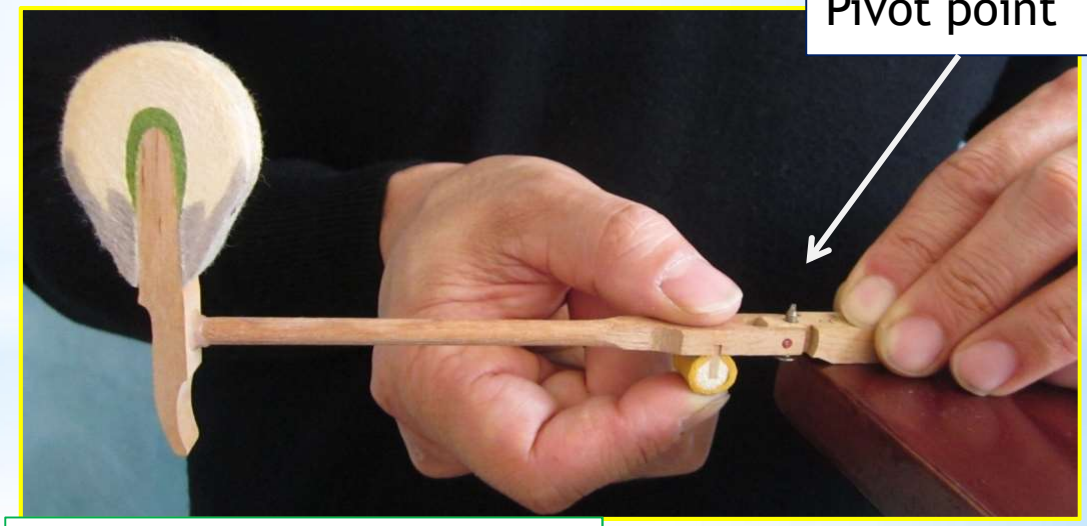
$$MoI_{(H)} = SW \times L_{(SW)}^{2}$$

Smaller MoI

Bigger MoI

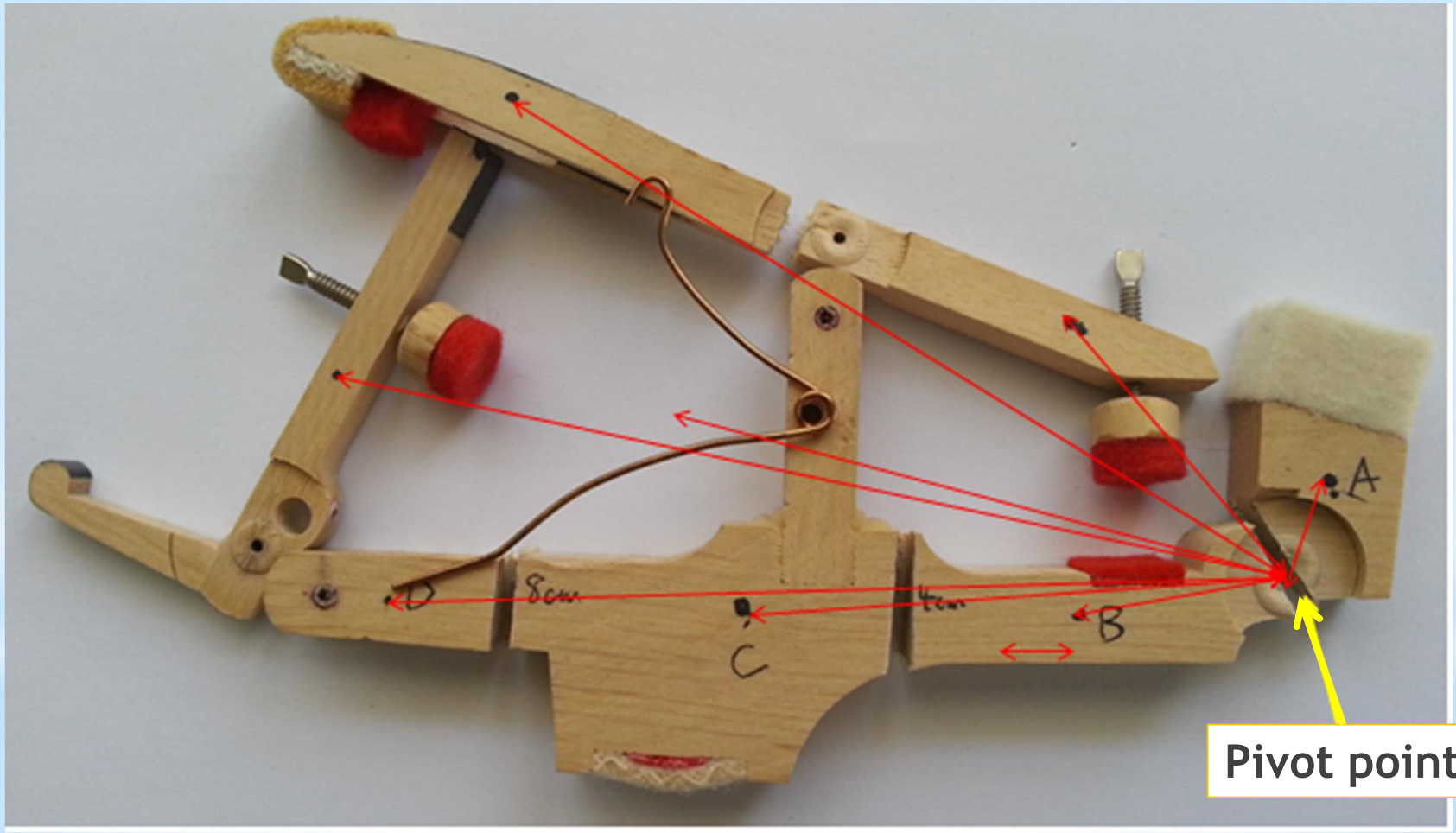
Lighter hammer head

Pivot point



Heavier hammer head

MoI of a wippen



$$\mathbf{MoI}_{(w)} = \Sigma\{\text{Mass of each part} \times \mathbf{L}_{(each)^2}\}$$

Moment of Inertia

- Kinetic resistance of a rotating object

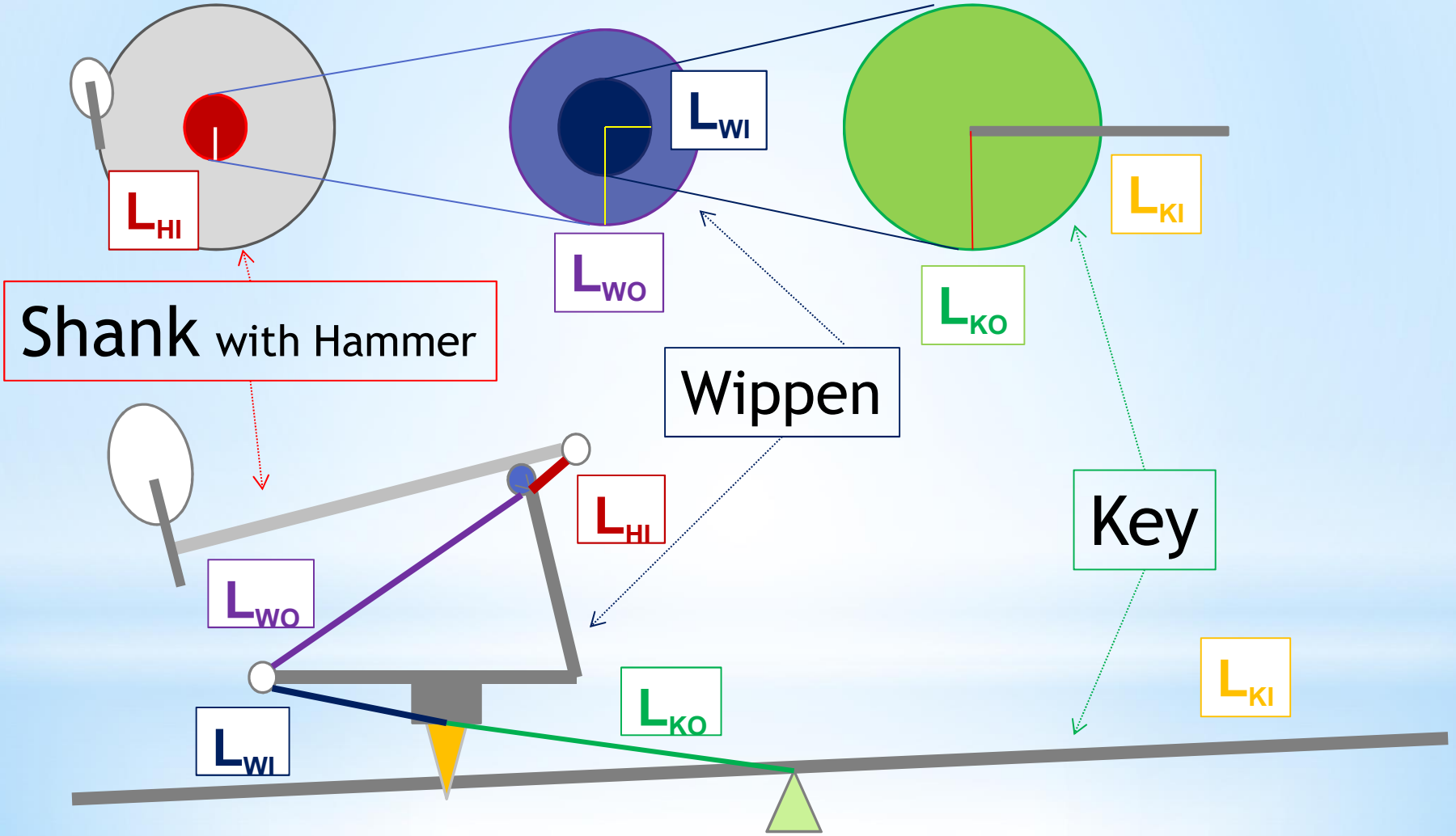
Linked Moment of Inertia

- Amount of the Moment of Inertia transferred through linked parts

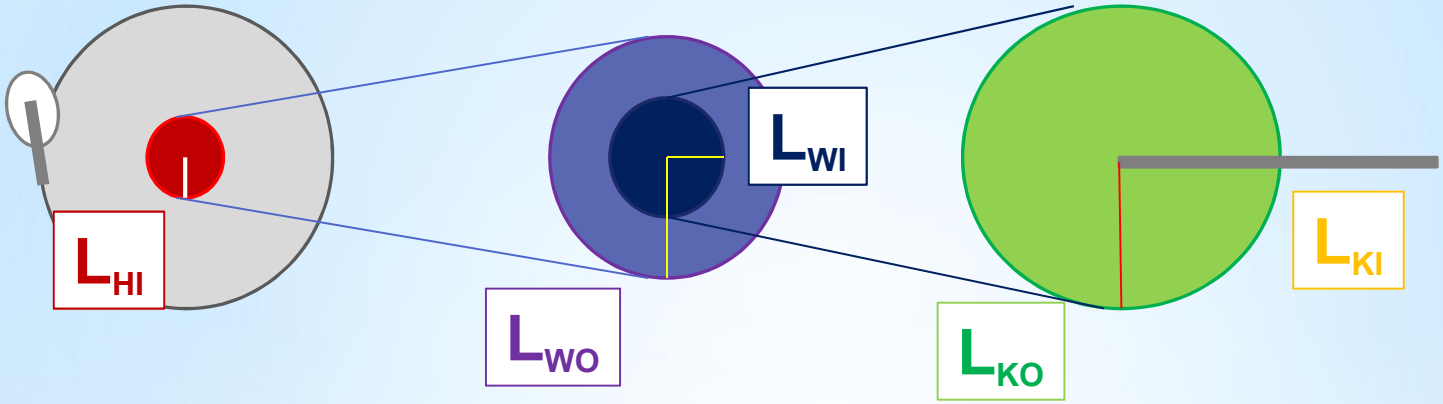
Gear Ratios

- Output/input ratio of linked rotating parts

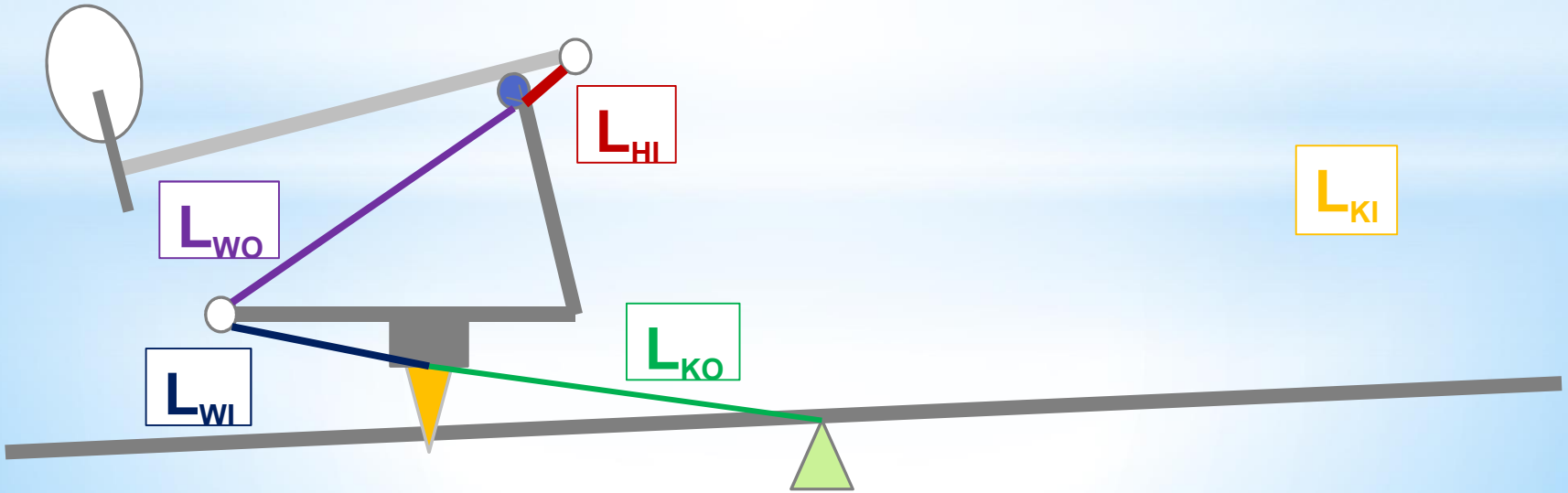
Piano action, Linked 3 rotating parts



How to feel the MoI of hammer at key

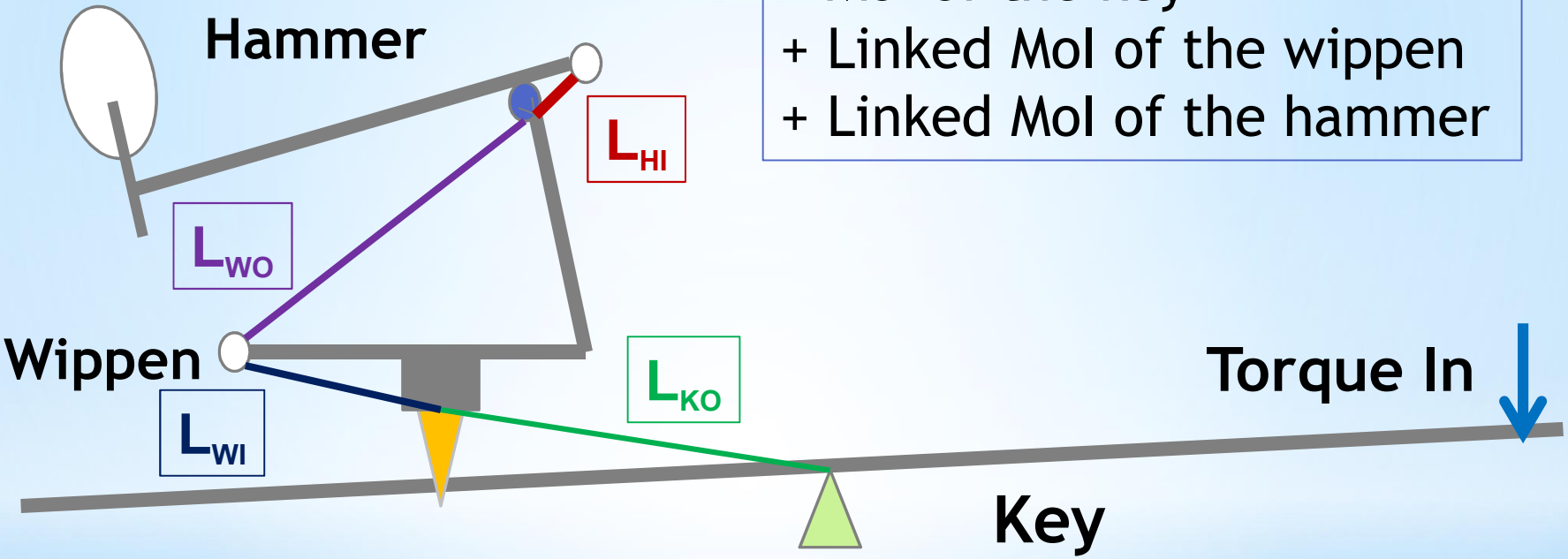


$$MoI_{(H\ at\ Key)} = MoI_{(H)} \times (L_{WO} / L_{HI} \times L_{KO} / L_{WI})^2$$



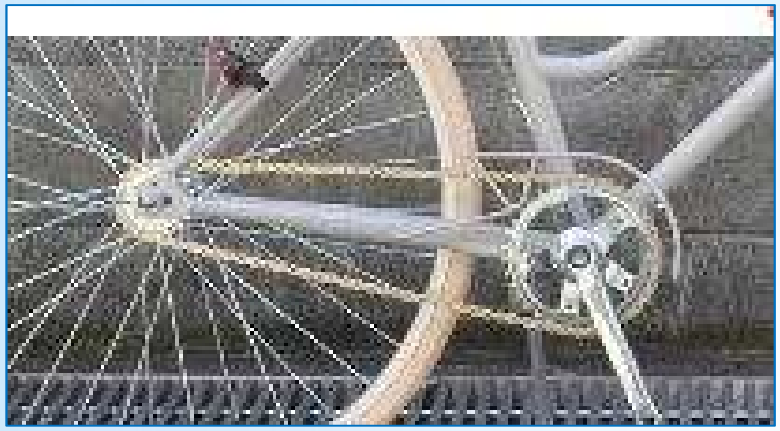
Linked Moment of Inertia

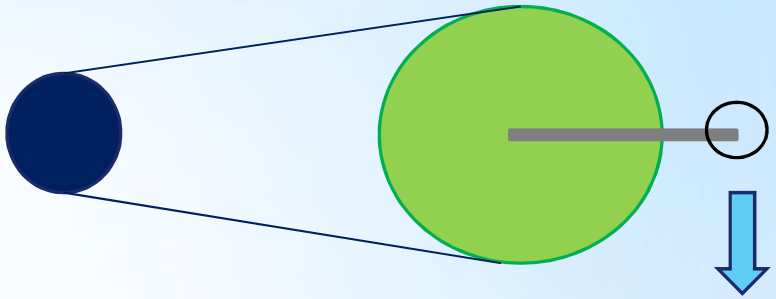
Whole MoI of the action
= MoI of the key
+ Linked MoI of the wippen
+ Linked MoI of the hammer



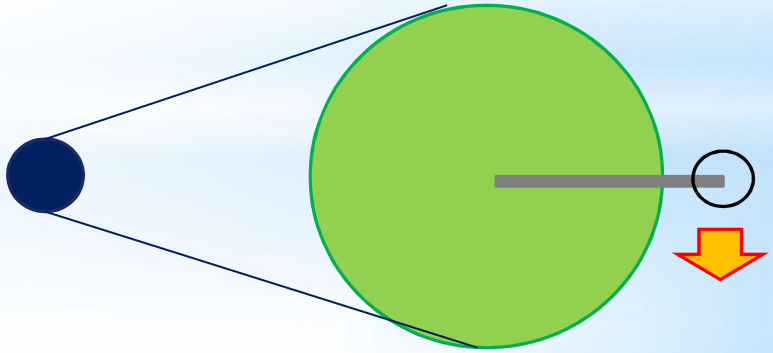
$$MoI_{(Whole\ action\ at\ key)} = MoI_{(K)} + MoI_{(W)} \times (L_{KO} / L_{WI})^2 + MoI_{(H)} \times (L_{WO} / L_{HI} \times L_{KO} / L_{WI})^2$$

Smaller Gear Ratio = Lighter to give acceleration



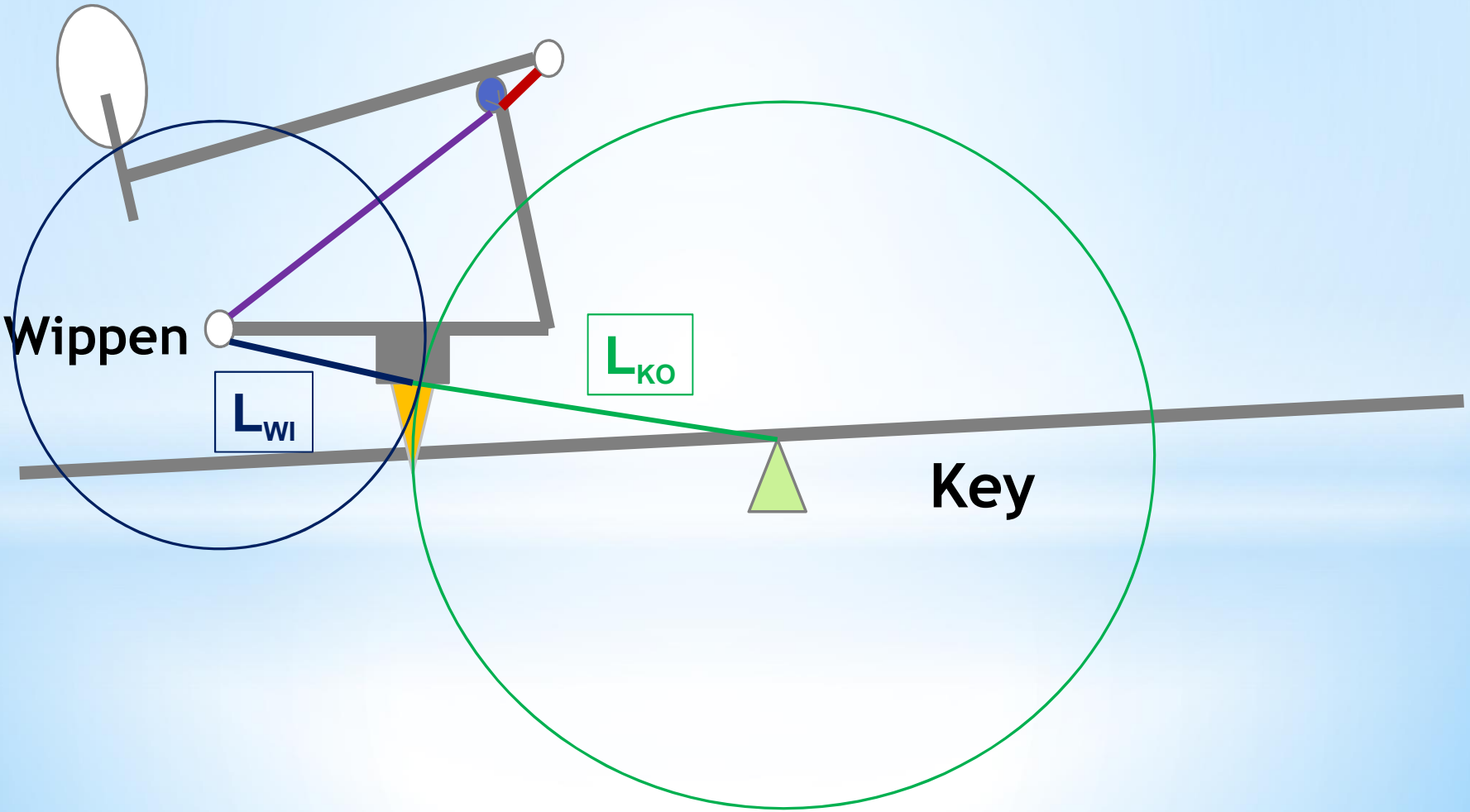


Bigger Gear Ratio = Heavier to give acceleration



Big piano or Small piano?

Gear ratio (wippen - key) → $(L_{KO} / L_{WI})^2$



Difference in $L_{(KO)}$

Sample calculation:

- Same hammer, wippen and MoI (key)
- Use each data of $L_{(KO)}$

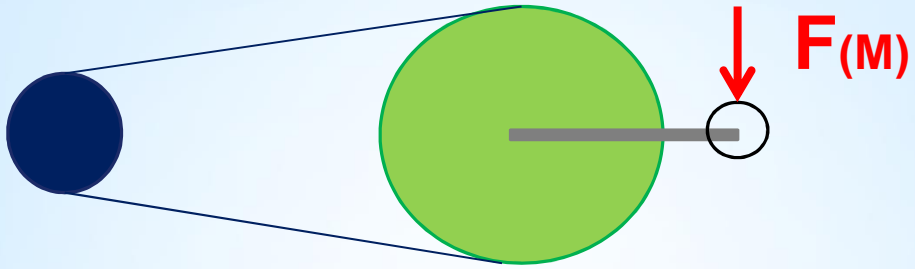
S&S model M Bottom B (L_{KO} = 12.1 cm)

➢ MoI (whole) : 202,000 g cm^2

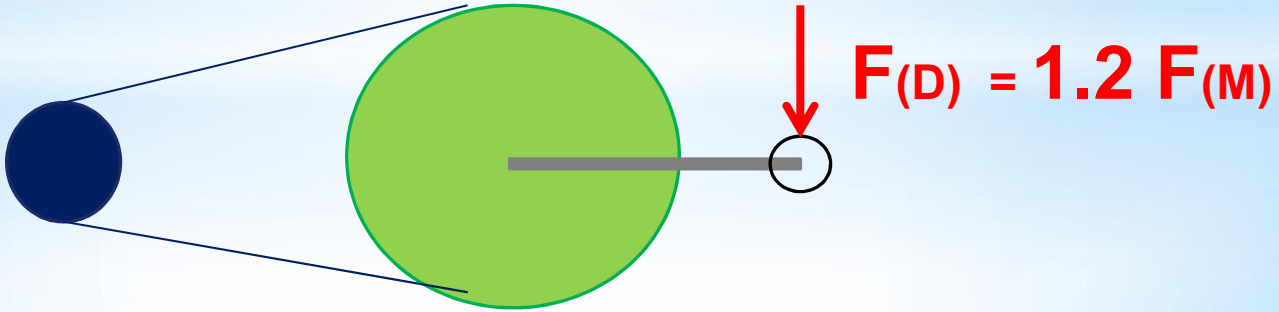
S&S model D Bottom B (L_{KO} = 16.5 cm)

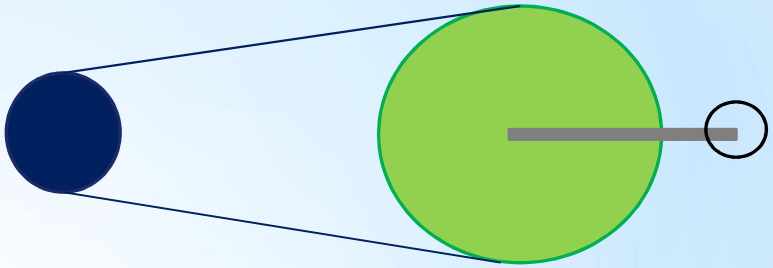
➢ MoI (whole) : 316,000 g cm^2

S&S M: L_{KI} = 23.2 cm, L_{KO} = 12.1 cm, MoI = 202,000



S&S D: L_{KI} = 31 cm, L_{KO} = 16.5 cm, MoI = 316,000





Smaller MoI = Easier to give acceleration
= Top speed is low

Kids: enjoy to ride
Professional: too light to ride, top speed is far slow

Relation between playing force and MoI

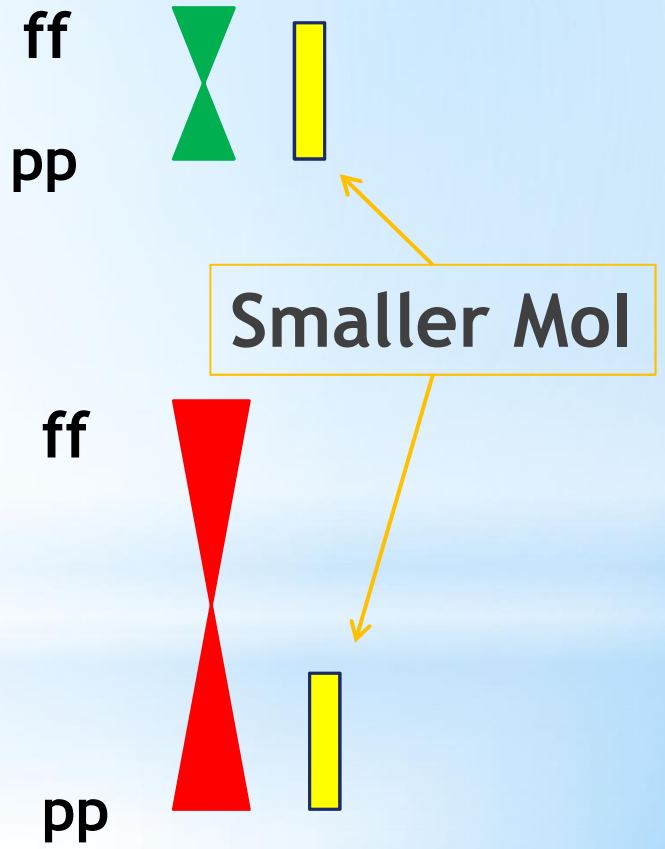
Play at lighter action with smaller MoI

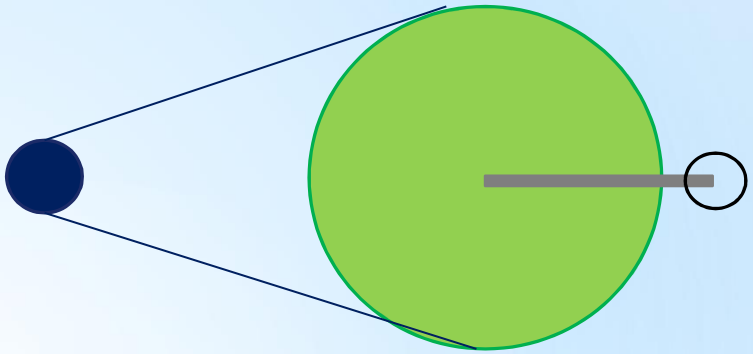
The pianist who has narrow band of playing force:

Feels controllable and expressive

The pianist who has wider band of playing force:

Feels limited volume and expression





Bigger MoI = Heavier to give acceleration
= Top speed is very fast

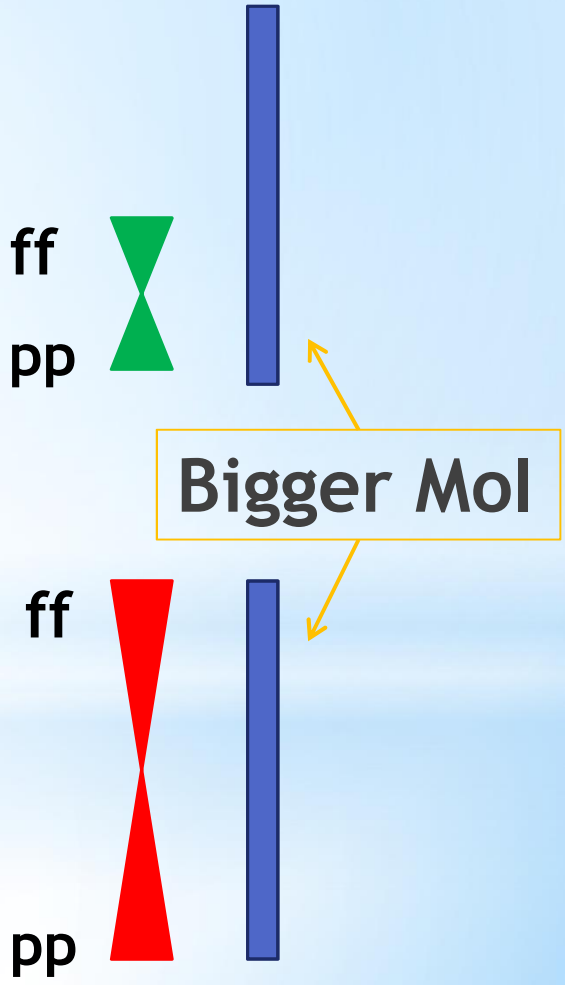
Kids: nearly impossible to ride as too heavy
Professional: manage-able, fastest top speed

Relation between playing force and MoI

Play at heavier action with bigger MoI

The pianist who has narrow band of playing force:

Feels too heavy



The pianist who has wider band of playing force:

Feels controllable and expressive

Where can we adjust?

- Strike Weight
- Ratios
- Location of key leads

Decide Strike Weight level

- Lighter hammer has better tremolo ability
- Heavier hammer has deeper and bigger tone

→ **Find desired SW with**

- **Preferred Strike Ratio**
- **Desired touchweight**
- **Tonal quality**

Set Ratios

- **Action Ratio** for standard regulation
- **Strike Ratio** for reasonable static touchweight
- **Gear ratios** are related with AR & SR

Adjusted by
- Capstan position,
- Cut balance punching cloth,
- Shim wippen heel

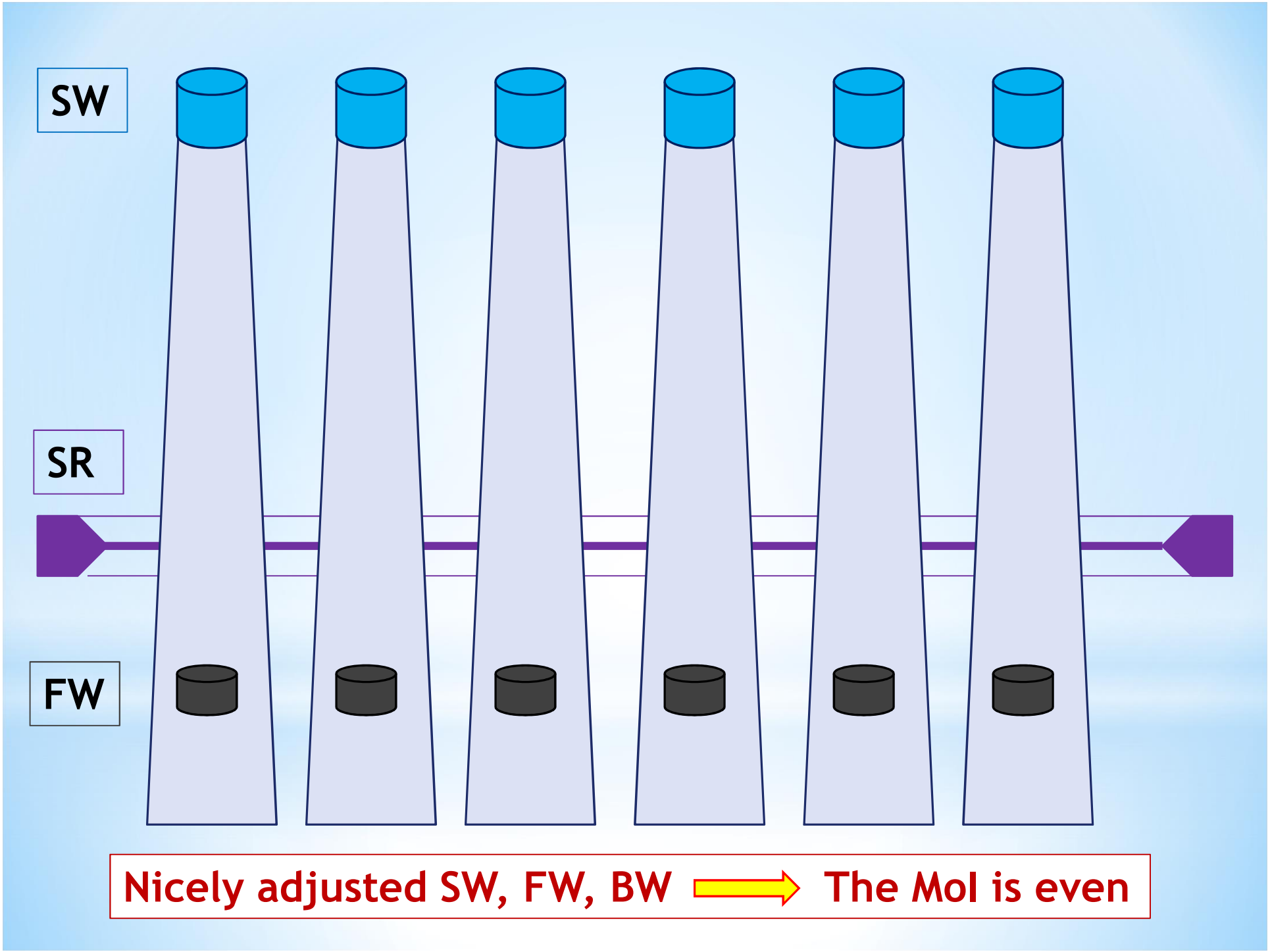
etc.

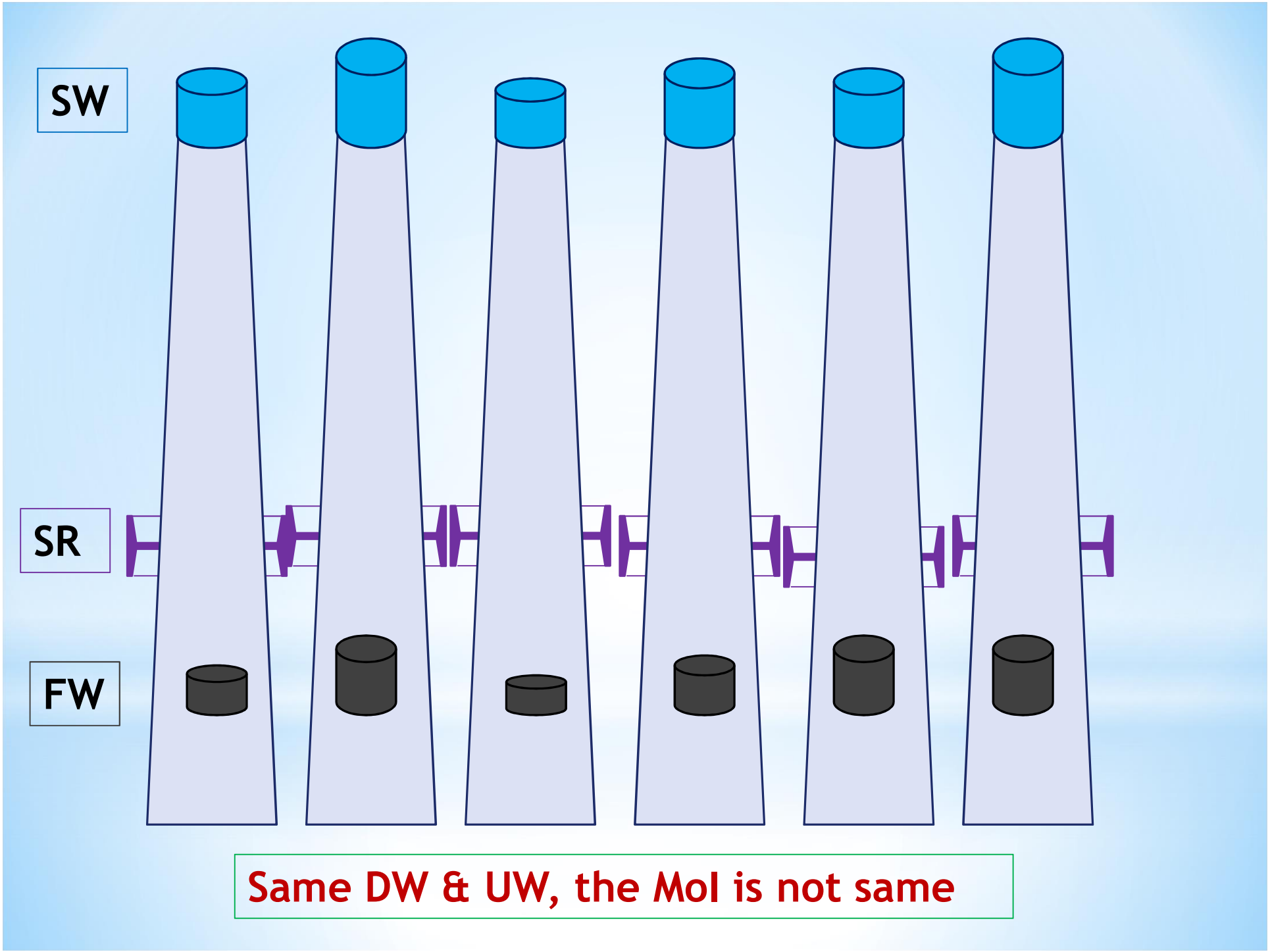
Location of key leads

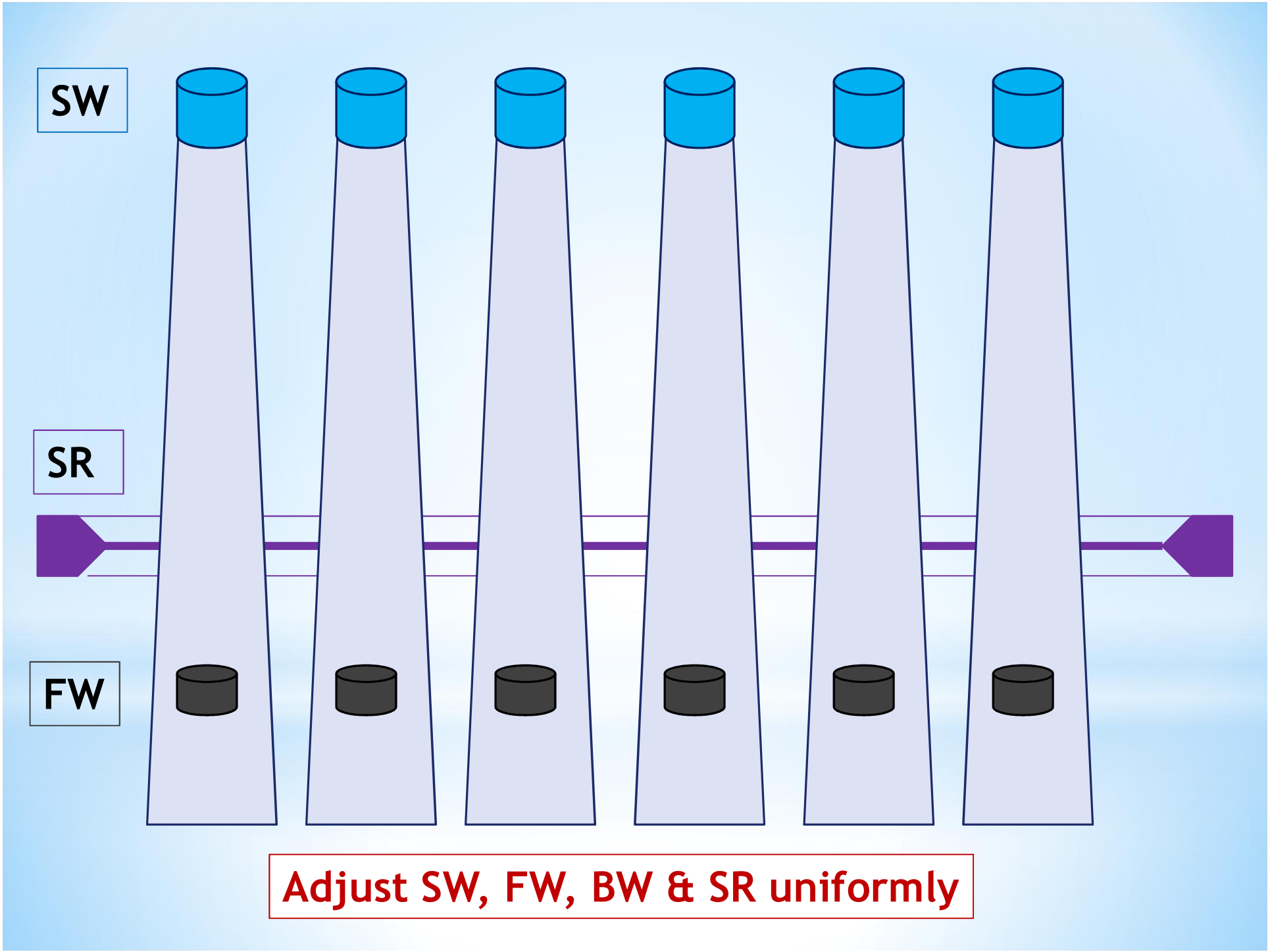
Locate key leads according to the amount of MoI

Get bigger MoI
- Locate leads outer side

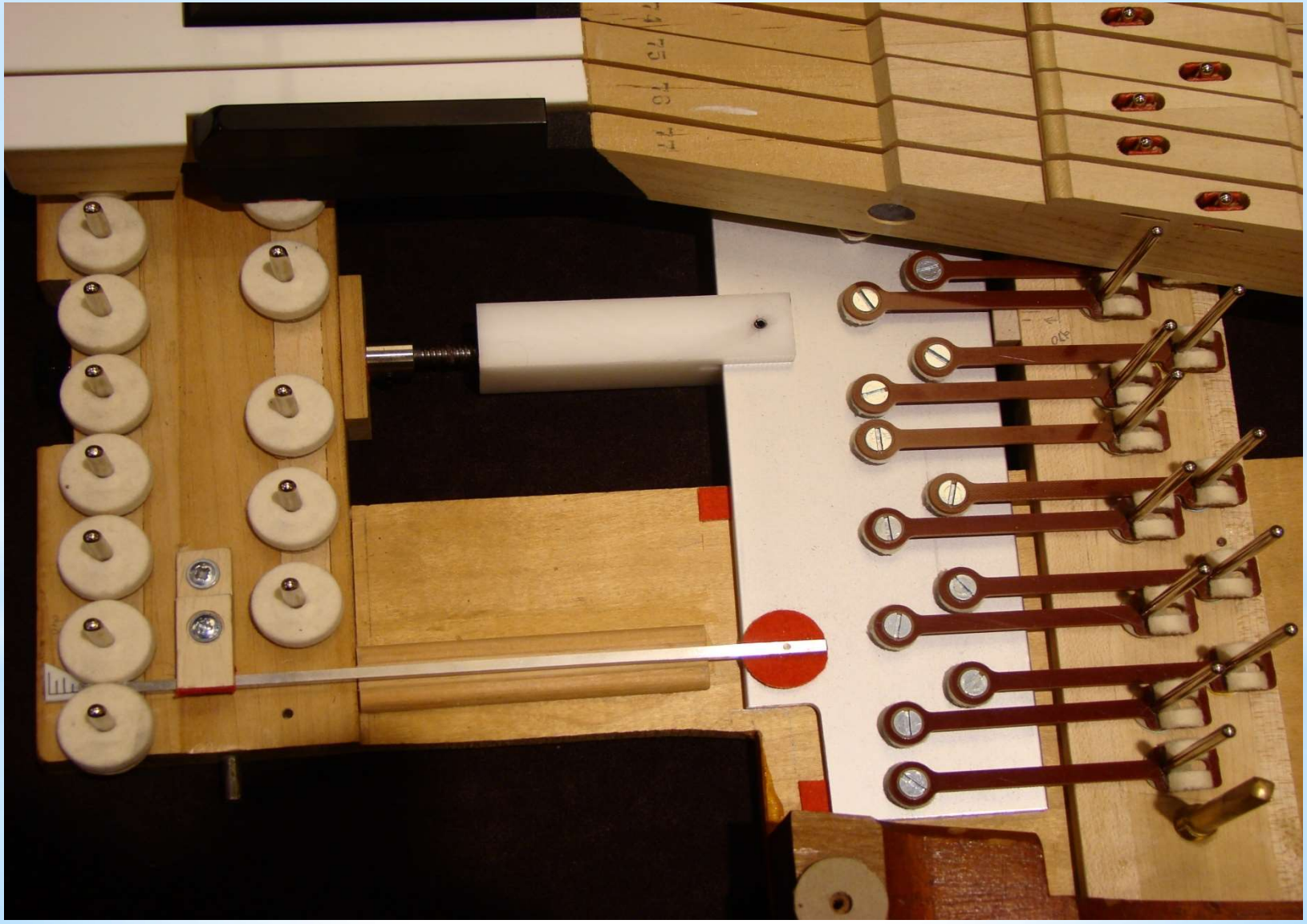
Get smaller MoI
- Locate leads closer to balance pin


SW
SR
FW
Nicely adjusted SW, FW, BW
The MoI is even


SW
SR
FW
Same DW & UW, the MoI is not same


SW
SR
FW
Adjust SW, FW, BW & SR uniformly

Stanwood Adjustable Leverage Action



Adjustable wippen heel