# Grand Action:
## A Balancing Act

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www.pianosinsideout.com

## The Touch Journey

- Static balancing (today)
- All aspects of balancing
  - David Stanwood's Precision Touch (comprehensive touch adjustment methodology)
  - Practical Touch Analysis (alternative measurement, adjustment methods)
- Understanding inertial behaviors (PTJ articles)
  - Fandrich-Rhodes (Weightbench, Inertial Touch Force)
  - Rick Voit (Key Force One, on-going research)
  - Yuji Nakamura (simplified analysis methods)

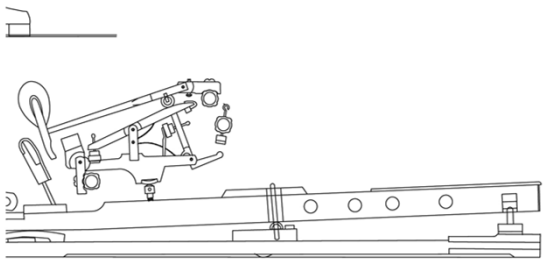
## Agenda

- Action as a lever
- Action forces
  - … and how they feel
- Measuring DW and UW
- Calculating BW and F
- How to Rebalance the Action

# Action as a Lever

## What is the piano action?

- A set of levers that transfers force from the finger to the hammer:



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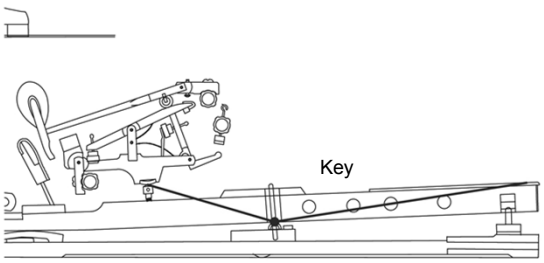

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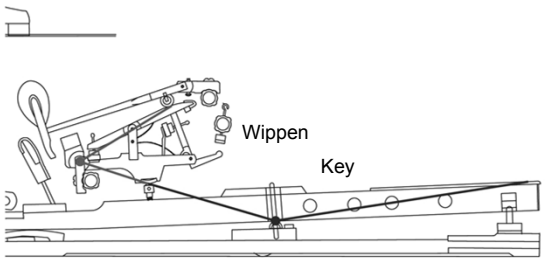


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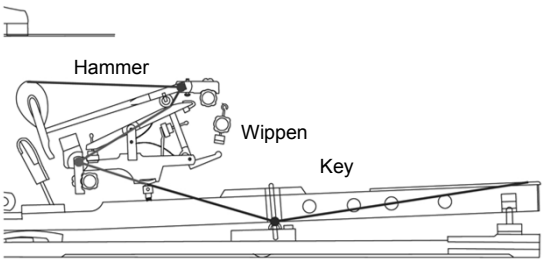
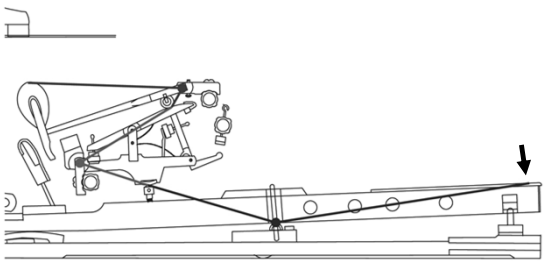



## How do the levers work?

- Applying force to the key:



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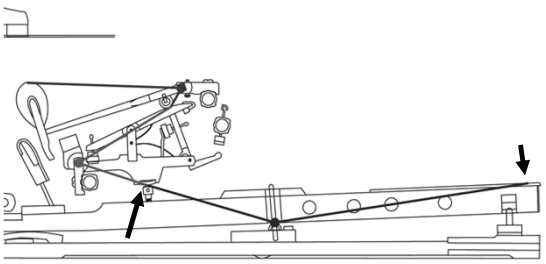
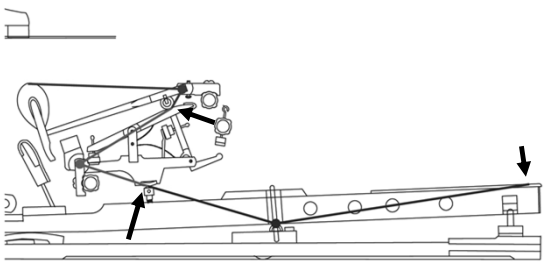


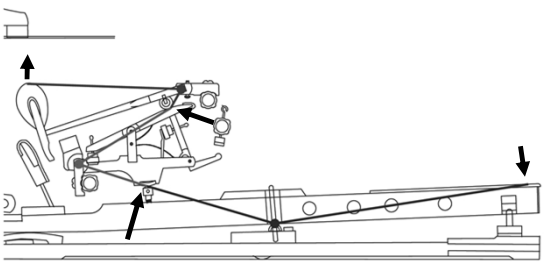
## How do the levers work?

which pushes the shank up:



## How do the levers work?

and lifts the hammer:



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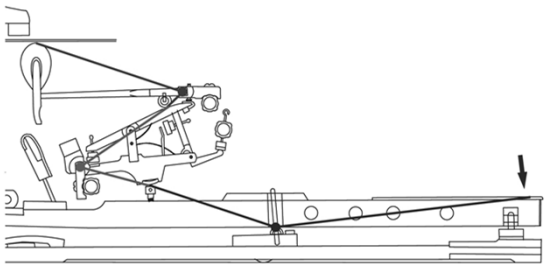

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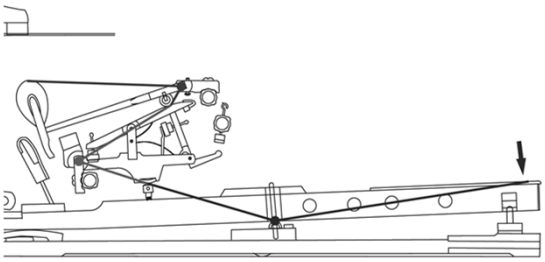
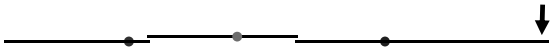


## How do the levers work?

The angle of each lever doesn't matter.
The action could be laid out like this:



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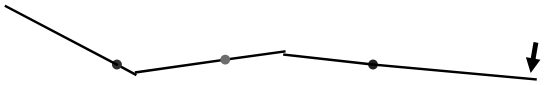
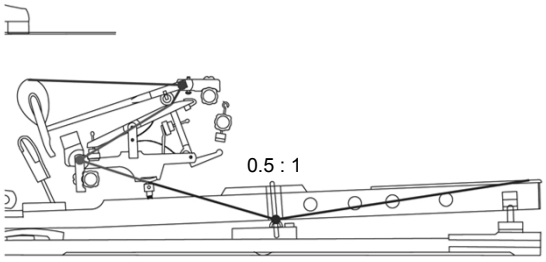


## How do the levers work?

- The levers have different ratios, which can be measured geometrically:

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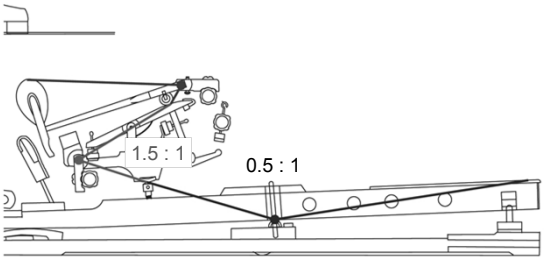

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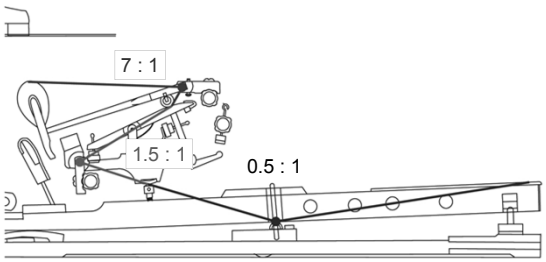
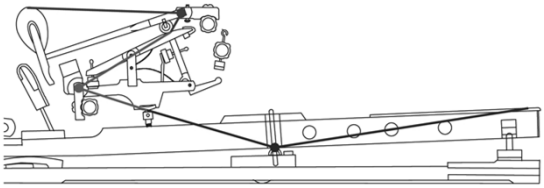



## How do the levers work?

- By combining them:

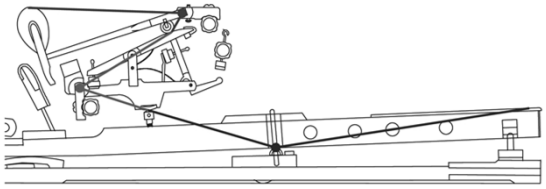
7 : 1 x 1.5 : 1 x 0.5 : 1



## How do the levers work?

and reducing:

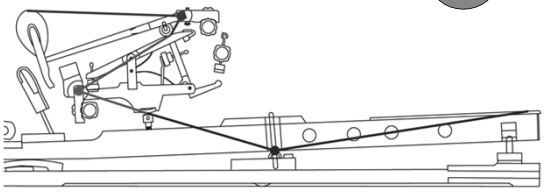
7 x 1.5 x 0.5



## How do the levers work?

we can calculate the total **geometric leverage ratio**:

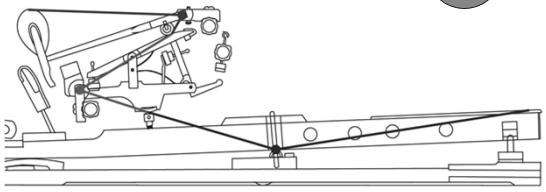
7 x 1.5 x 0.5 = 5.25 : 1



## How do the levers work?

approximate ratio between:
**finger force** and **hammer "weight"**, or …

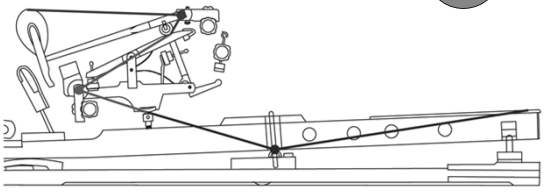
7 x 1.5 x 0.5 = 5.25 : 1



## How do the levers work?

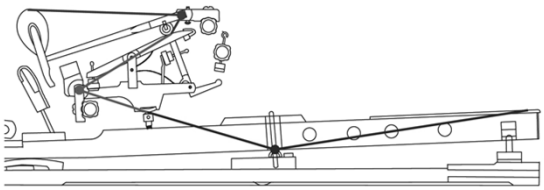
**force leverage ratio**.

7 x 1.5 x 0.5 = 5.25 : 1



## Action as a single lever

- To better visualize the action leverage ratio, let's reduce the action to a see-saw:



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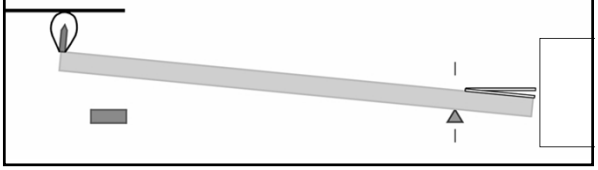

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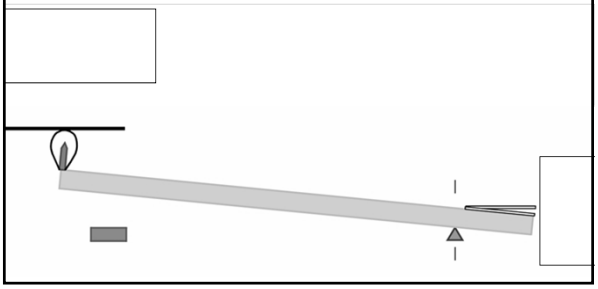

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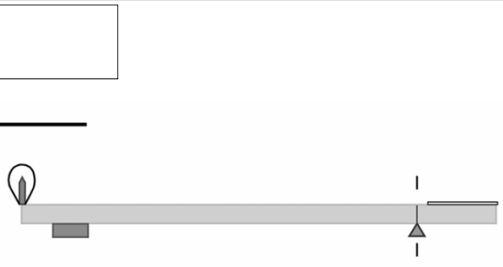
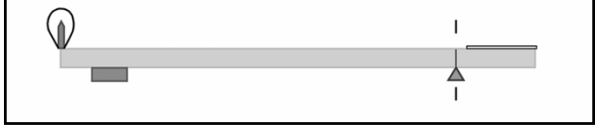


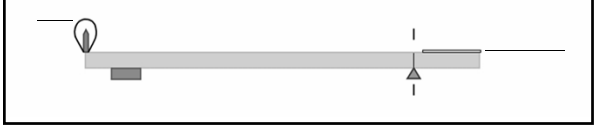
## Action as a single lever

By observing the weights and distances on either end:



## Action as a single lever

Our extra long key translates:



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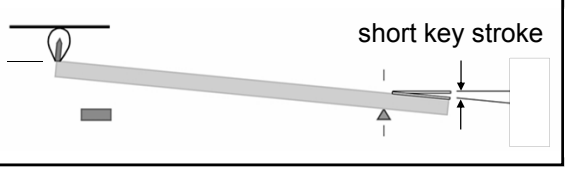


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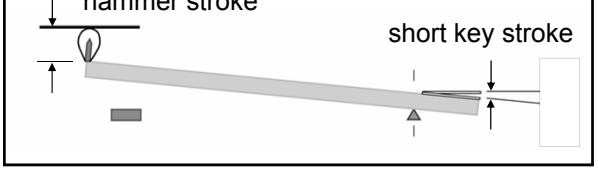


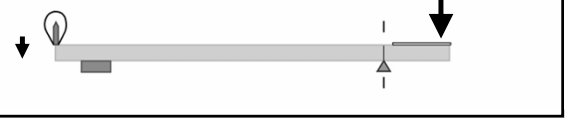

## Action as a single lever

Our extra long key translates:

and:

low hammer weight

to greater
“play weight”



## If we know the leverage ratio …

… we can measure one end
and calculate the other end

and:

low hammer weight

to greater
“play weight”

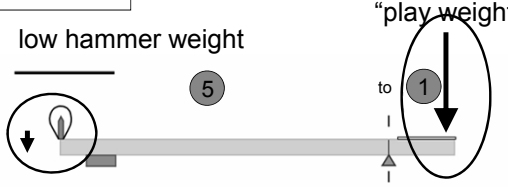
## If we know the leverage ratio …

… or vice versa

and:

low hammer weight

to greater "play weight"



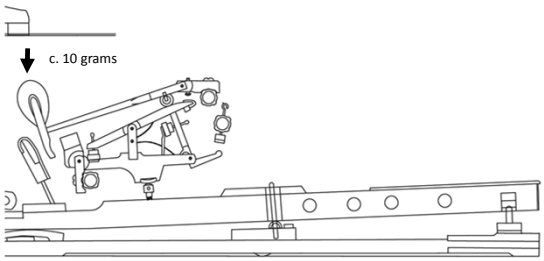

## Summary of grand piano leverage

- 3 levers = single lever (seesaw)
- Force leverage (close to escapement) ~ geometric leverage
- Leverage translates:
  - Long blow distance to Short dip
  - Light hammer to Greater "play weight"
- Action leverage allows predicting the force or weight on the other end of the action

# Action Forces

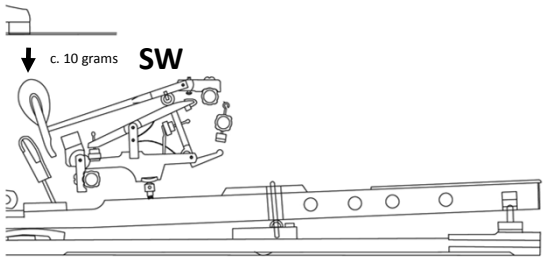
## What makes the piano action heavy or light?

- The hammer on one end is pulled down by gravity:



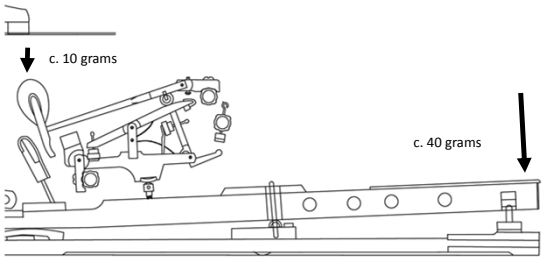

## What makes the piano action heavy or light?

- The weight of the hammer and shank is called strike weight (**SW**) :



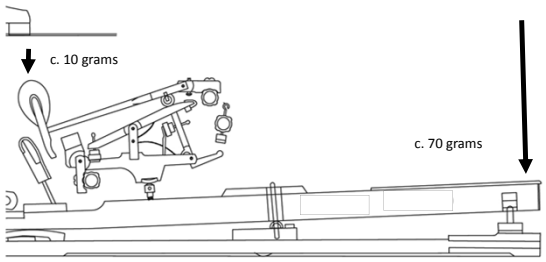

## What makes the piano action heavy or light?

- To overcome **SW**, some force is needed to depress the key:



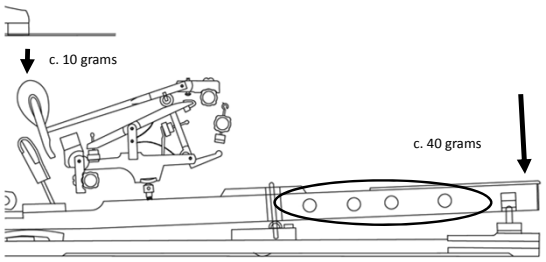
## What makes the piano action heavy or light?

- Without leads in keys, the finger force would need to be too great:



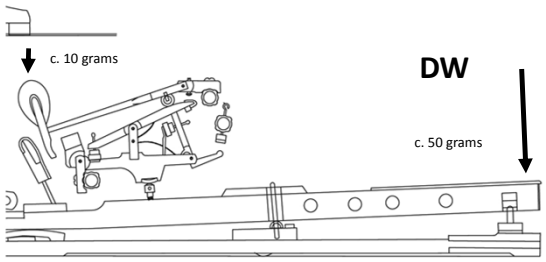

## What makes the piano action heavy or light?

- Leads reduce the needed force.



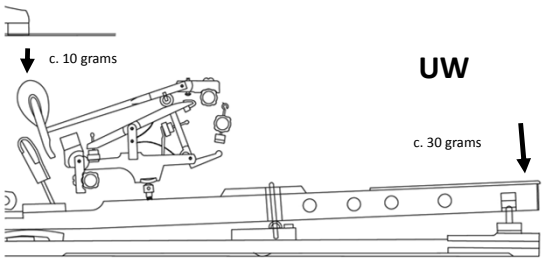

## What makes the piano action heavy or light?

- To start depressing the key, the finger applies the downweight force (**DW**):



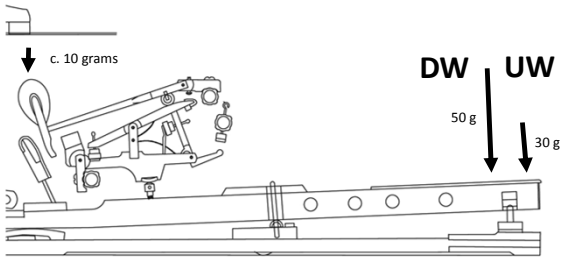

## What makes the piano action heavy or light?

- … and to allow the key to return slowly, the finger holds the key with the upweight force (**UW**):



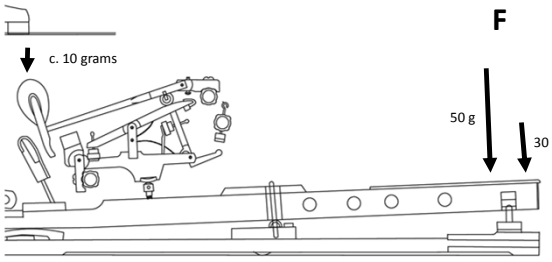

## What makes the piano action heavy or light?

- What causes the discrepancy between **DW** and **UW**?



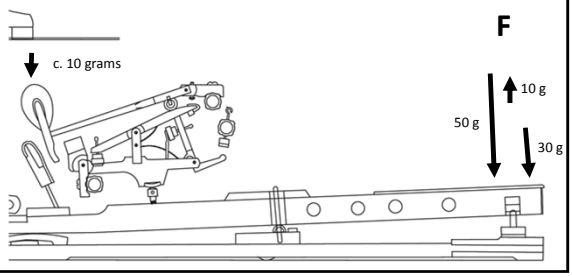

## What makes the piano action heavy or light?

- Friction (**F**)!



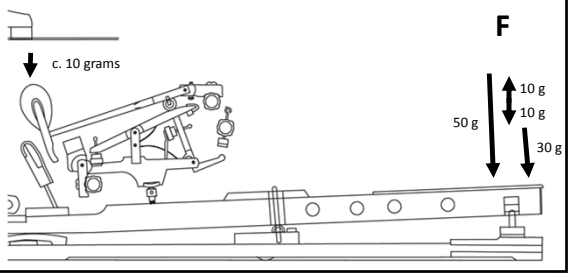
## What makes the piano action heavy or light?

- Friction (**F**)! Half during downstroke:



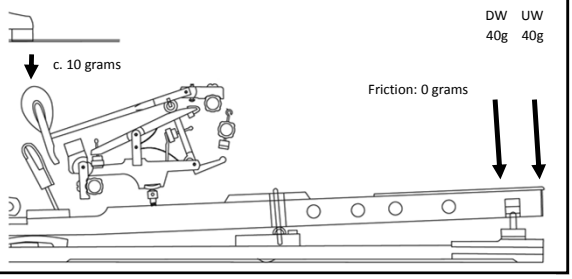

## What makes the piano action heavy or light?

- Friction (**F**)! The other half during upstroke:



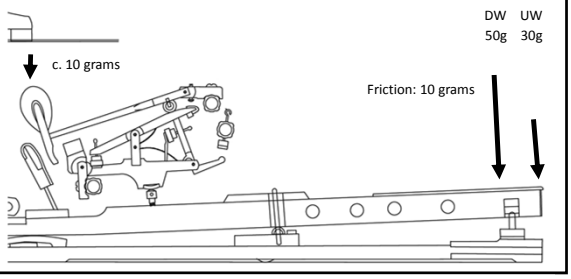

## What makes the piano action heavy or light?

- Without friction **DW** and **UW** would be the same:




## What makes the piano action heavy or light?

- Friction pushes **DW** and **UW** apart:

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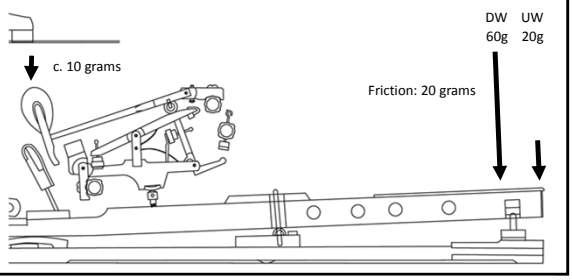
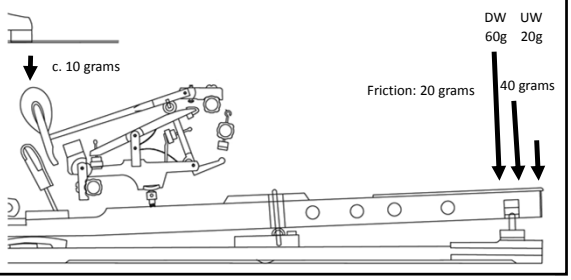



## What makes the piano action heavy or light?

- … but the average of **DW** and **UW** remains the same:



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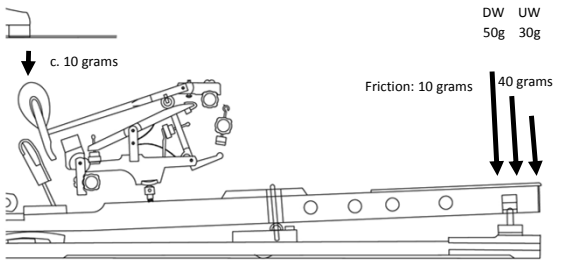


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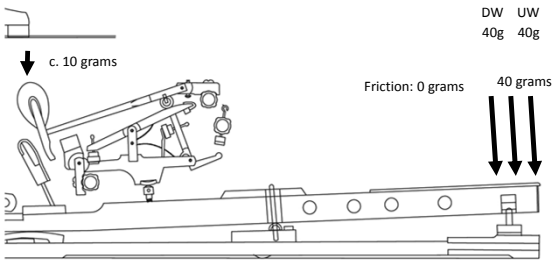
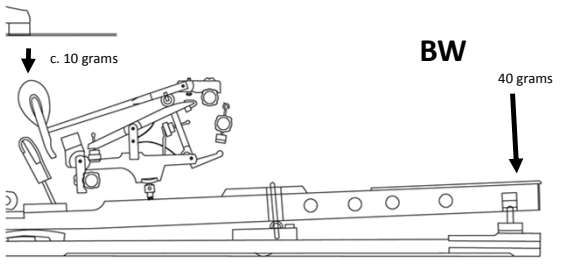


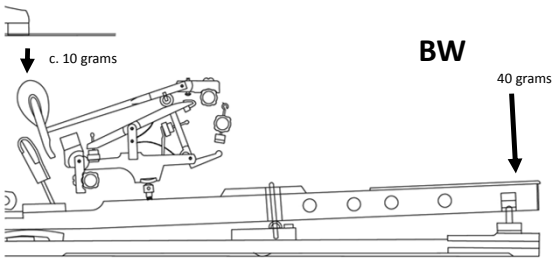

## What makes the piano action heavy or light?

- This imaginary force is called balance weight (**BW**).




## What makes the piano action heavy or light?

- BW is very useful because it allows you to ignore discrepancies in friction (**F**) during balancing.



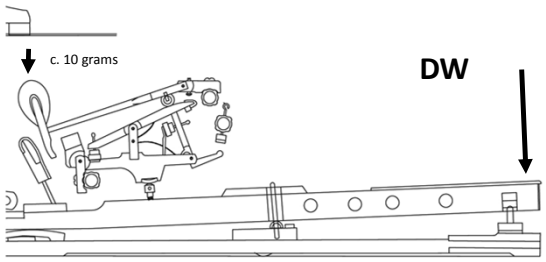

## Summary of action forces

- Hammer and shank "radius" weight is strike weight (**SW**)
- The weight of the front of the key is front weight (**FW**)
- Downweight (**DW**)
- Upweight (**UW**)
- Balance weight (**BW**) is avg. of DW and UW
- Friction (**F**) is half of discrepancy between DW and UW
- Friction (**F**) is the discrepancy between BW and DW; BW and UW

## How Do Action Forces Feel?

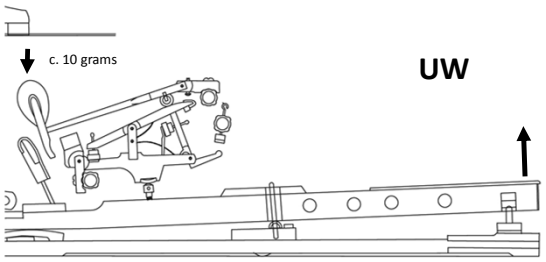
## How do action forces feel?

- **DW** feels **resistive**.



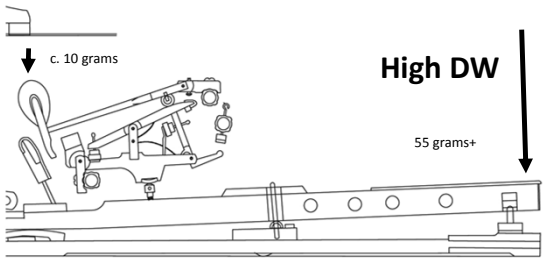

## How do action forces feel?

- **UW** feels **repelling**.



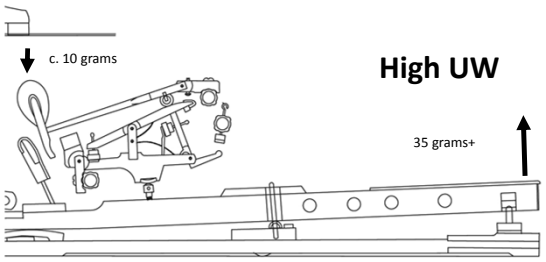

## How do action forces feel?

- High **DW slows you down**. It makes you **strain** to play *ppp*, reducing control.



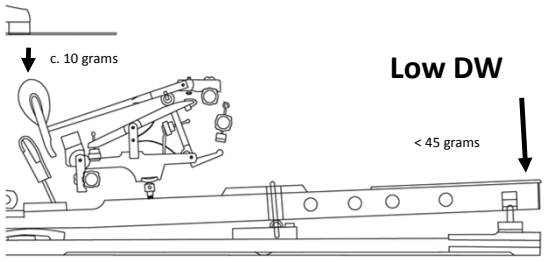

## How do action forces feel?

- High **UW speeds up** repetition by pushing the finger up, but this feels uncomfortable.



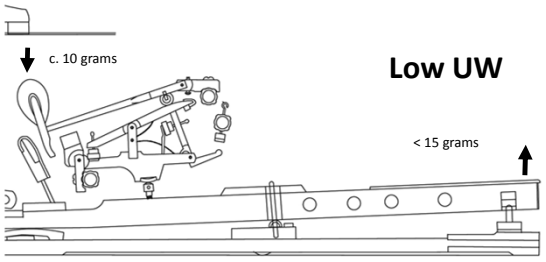

## How do action forces feel?

- Low **DW** feels like nothing to bite into. Too little resistance feels flyaway, also reducing control.




## How do action forces feel?

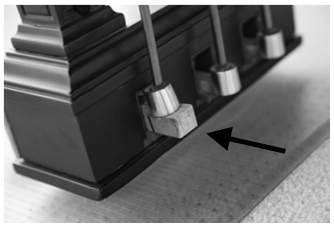
- Low **UW** feels sluggish, as if the action lags behind you. Repetition is impeded. Dancing keys?



# Measuring DW and UW

## Prepare

- First, **prop the pedal** up with a wedge

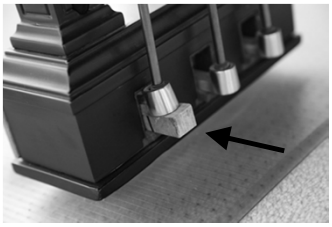


… or place wedge between rod and trapwork lever

… or clamp damper up, away from strings

## Prepare

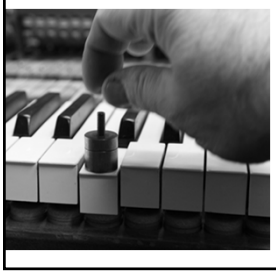
- First, **prop the pedal** up with a wedge



Why?

## Measure Downweight (**DW**)

Place the weight so its center is ½" (13 mm) in from the edge of the key top

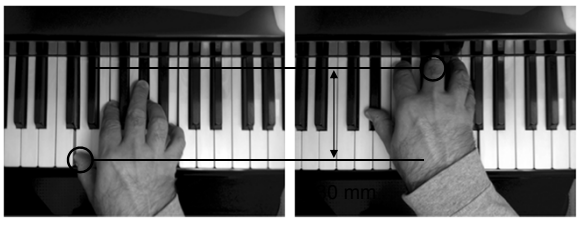


David Stanwood's Standard Measurement Position (SMP)

## Measure Downweight (**DW**)

- Where you measure matters.
  Compare these two **touch points**:

**1.** **2.**




## Measure Downweight (**DW**)

- The difference might be:

| | 1. | 2. |
|---|---|---|
| **DW** | 47 g | 98 g |
| **UW** | 23 g | 54 g |
| **BW** | 35 g | 76 g |
| **Friction** | 12 g | 22 g |
| **Leverage** | 5.5 : 1 | 11.4 : 1 |
| **Key dip** | 10 mm | 5.2 mm |

## Measure Downweight (**DW**)

### Why?

| | 1. | 2. |
|---|---|---|
| **DW** | 47 g | 98 g |
| **UW** | 23 g | 54 g |
| **BW** | 35 g | 76 g |
| **Friction** | 12 g | 22 g |
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## Action as a single lever

Because we are pressing the key here:

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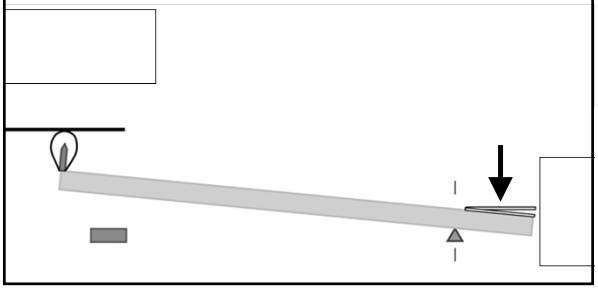
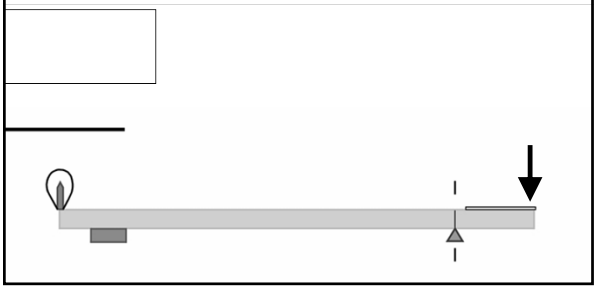


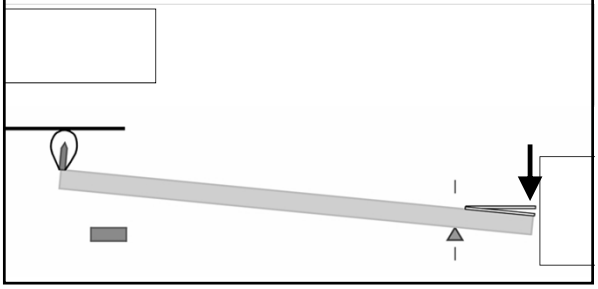
## Action as a single lever

… instead of here:



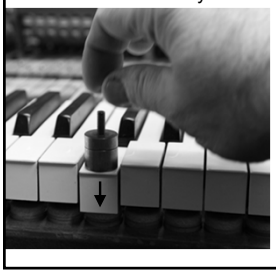
## Action as a single lever

… instead of here:



## Measure Downweight (**DW**)

Know your weights (can be several grams off)
Pre-depress the key to 4 mm and let go.
The key should sink slowly to about 7 mm.



## Measure Upweight (**UW**)

Pre-depress the key against the letoff bump (7-8 mm) and let go.

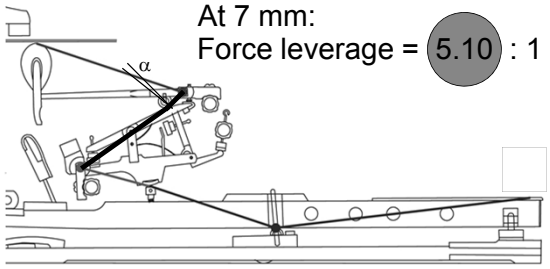
The key should lift slowly to c. 4 mm dip.

## Measure Upweight (**UW**)

We want all measurements to be centered around the 6 mm dip …

## Measure Upweight (**UW**)

because at 6 mm dip, force leverage is closest to geometric leverage …




At 7 mm:
Force leverage = 5.10 : 1

## Measuring

## Measuring

- Measure/calculate for notes C1, C3, C5, C7:

  Use Touchweight worksheet from *Pianos Inside Out* (p. 277) or fill out:

| Note: | C1 | C3 | C5 | C7 |
|---|---|---|---|---|
| **DW:** | | | | |
| **UW:** | | | | |
| **BW:** | | | | |
| **F:** | | | | |

## Measuring

- Sample measurements:

| Note: | C1 | C3 | C5 | C7 |
|---|---|---|---|---|
| **DW:** | 52 g | 50 g | 47 g | 48 g |
| **UW:** | 22 g | 26 g | 25 g | 32 g |
| **BW:** | | | | |
| **F:** | | | | |

## Calculating balance weight (**BW**)

**(DW + UW) / 2 =**
(52 + 22) / 2 =
74 / 2 =
37 g

Recommended range: 33 – 41 g

Steinway standard: 35 g

Recommended: 37-38 g to allow reducing the hammer weight (**SW**) through hammer filing

## Calculating friction (**F**)

**(DW - UW) / 2 =**
(52 - 22) / 2 =
30 / 2 =
15 g

Recommended ranges:
A0: 11 – 17 g
C4: 9 – 15 g
C8: 7 – 13 g

## Measuring

- Sample measurements:

| Note: | C1 | C3 | C5 | C7 |
|---|---|---|---|---|
| **DW:** | 52 g | 50 g | 47 g | 48 g |
| **UW:** | 22 g | 26 g | 25 g | 32 g |
| **BW:** | | | | |
| **F:** | | | | |

## Measuring

- Sample measurements and calculations:

| Note: | C1 | C3 | C5 | C7 |
|---|---|---|---|---|
| **DW:** | 52 g | 50 g | 47 g | 48 g |
| **UW:** | 22 g | 26 g | 25 g | 32 g |
| **BW:** | 37 g | 38 g | 36 g | 40 g |
| **F:** | 15 g | 12 g | 11 g | 8 g |

## DW/UW matrix (for note C4)

**DW**:

| **UW**: | **Low** < 45 g | **High** > 53 g |
|---|---|---|
| **Low** < 21 g | ▪Light<br>▪Dynamics: either *p* of *f*<br>▪Poor repetition<br>▪Dancing keys | ▪Resistive (“heavy”)<br>▪Unresponsive<br>▪Sluggish<br>▪High friction |
| **High** > 29 g | ▪Flyaway<br>▪Nothing to bite into<br>▪Repels fingers<br>▪Low friction | ▪Heavy<br>▪Hard to play *ppp*<br>▪Responsive<br>▪Good repetition |

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leads

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c.

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friction

## How to Rebalance the Action?

## How to rebalance the action?

- Alter strike weight (**SW**) (changes tone):
  - File hammers
  - Thin/taper the hammers
  - Replace with lighter hammers
  - File shanks (don't!)
  - Add clips
  - Install lead wire
- Change the action leverage ratio (**R**) (changes key dip)
- Add or remove key leads (alter **FW**)

big topics for another time!

## Limits of action balancing

- No idea about inertial effects of a particular configuration
- Doesn't suggest what to "fix"
- Only focused on *ppp* response
- Friction can be unbalanced and misleading

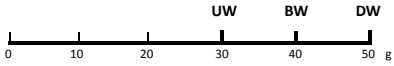
Never install key leads or modify action leverage without understanding all aspects of touch adjustment

Thank you!

# Advantages of Working with Balance Weight

## Why should we go by balance weight?

- **Balance weight** (**BW**) is the average of (or "value between") downweight (**DW**) and upweight (**UW**):

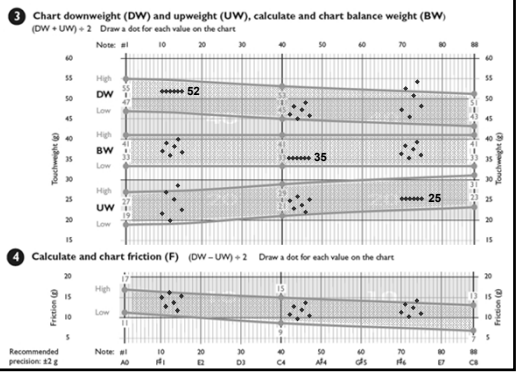



BW = (DW + UW) / 2
BW = (50 g + 30 g) / 2
BW = 80 g / 2
BW = 40 g

In even the best grands, **Friction** varies by 2-4 g note to note. How does that affect touch if we aim for a smooth:

- DW
- BW
- UW?

## Why should we go by balance weight?




## Why should we go by balance weight?

- If DW is consistent, UW varies by **twice as much** as BW
- If UW is consistent, DW varies by **twice as much** as BW
- If BW is consistent, DW and UW vary by **same amount**

## Why should we go by balance weight?

- **Friction** (**F**) is half the difference between downweight and upweight:

  F = (DW - UW) / 2

- Even friction = consistent DW, UW