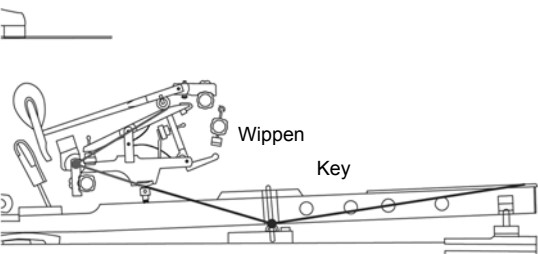


What is the piano action?

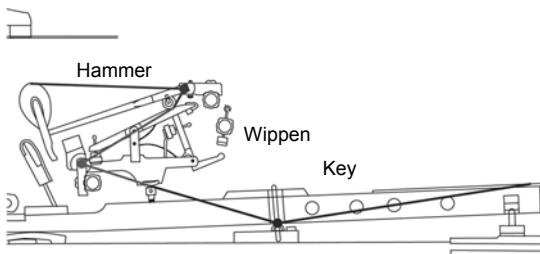
- A set of levers that transfers force from the finger to the hammer:



This diagram shows the piano action mechanism in its resting state. A key is shown at the bottom, connected to a hammer flange. Above the key is the hammer flange, which is connected to the hammer butt. The hammer butt is connected to the hammer flange, which is connected to the hammer butt. The hammer butt is connected to the hammer flange, which is connected to the hammer butt. The hammer butt is connected to the hammer flange, which is connected to the hammer butt. The hammer butt is connected to the hammer flange, which is connected to the hammer butt.

What is the piano action?

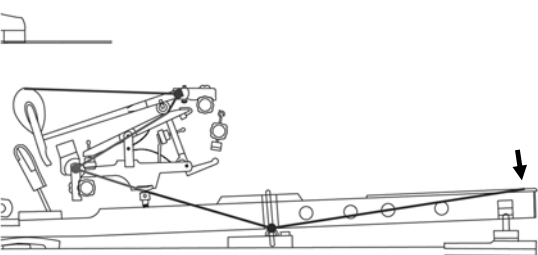
- A set of levers that transfers force from the finger to the hammer:



This diagram shows the piano action mechanism in its resting state. A key is shown at the bottom, connected to a hammer flange. Above the key is the hammer flange, which is connected to the hammer butt. The hammer butt is connected to the hammer flange, which is connected to the hammer butt. The hammer butt is connected to the hammer flange, which is connected to the hammer butt. The hammer butt is connected to the hammer flange, which is connected to the hammer butt.

How do the levers work?

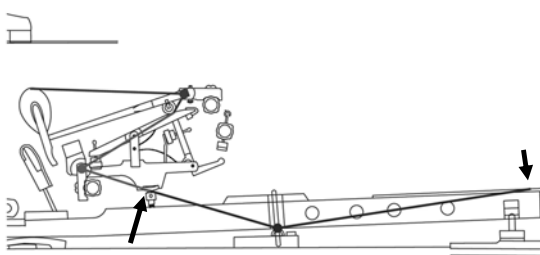
- Applying force to the key:



This diagram shows the piano action mechanism in its resting state. A key is shown at the bottom, connected to a hammer flange. Above the key is the hammer flange, which is connected to the hammer butt. The hammer butt is connected to the hammer flange, which is connected to the hammer butt. The hammer butt is connected to the hammer flange, which is connected to the hammer butt. The hammer butt is connected to the hammer flange, which is connected to the hammer butt.

How do the levers work?

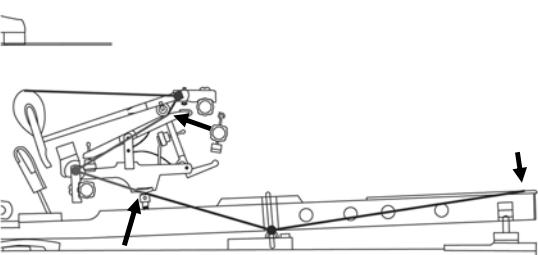
lifts the wippen:



This diagram shows the piano action mechanism in its resting state. A key is shown at the bottom, connected to a hammer flange. Above the key is the hammer flange, which is connected to the hammer butt. The hammer butt is connected to the hammer flange, which is connected to the hammer butt. The hammer butt is connected to the hammer flange, which is connected to the hammer butt. The hammer butt is connected to the hammer flange, which is connected to the hammer butt.

How do the levers work?

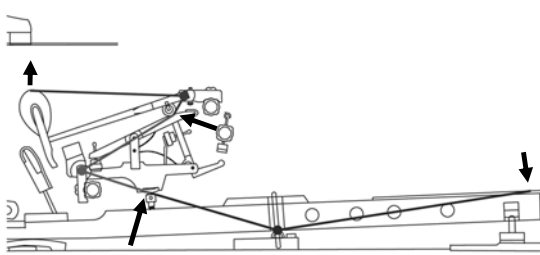
which pushes the shank up:



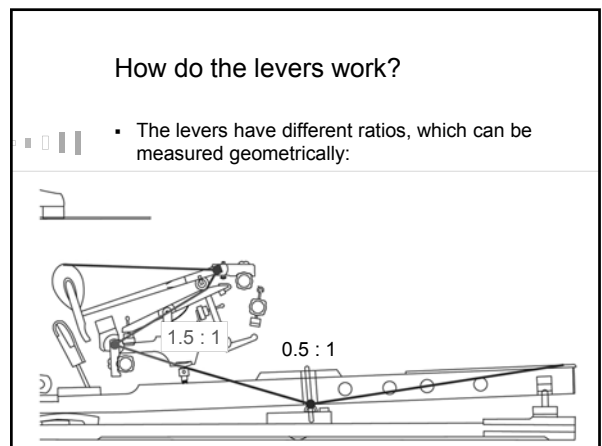
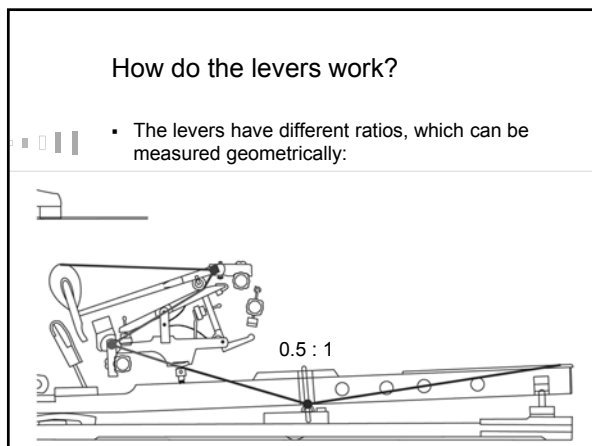
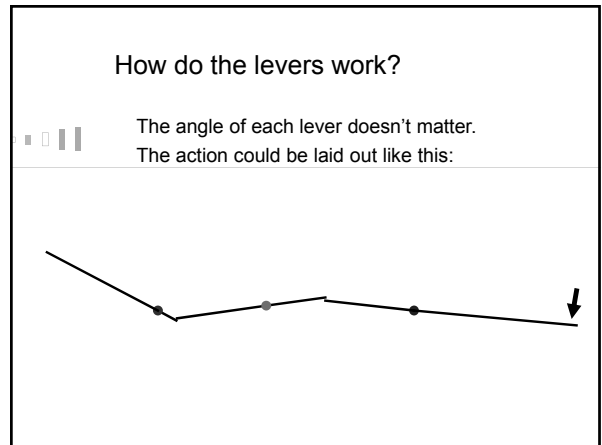
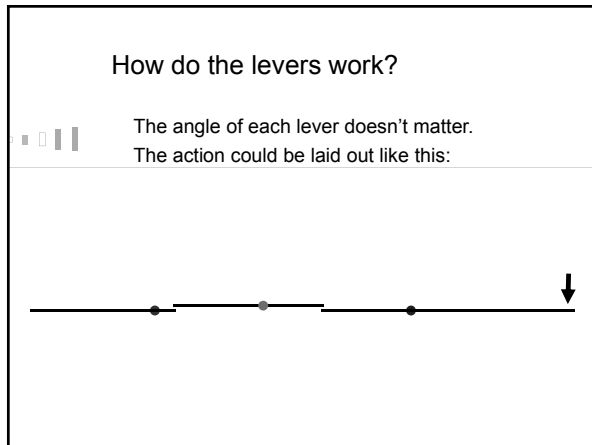
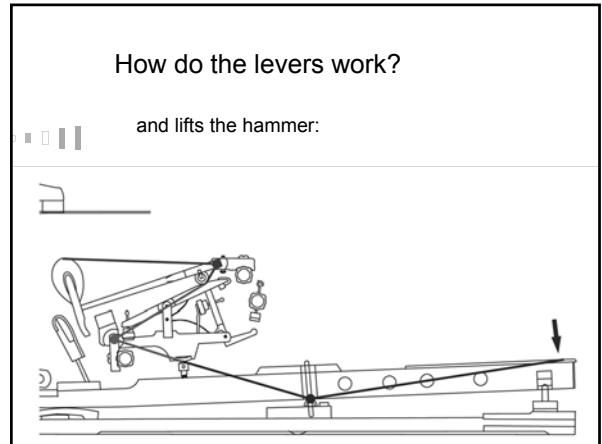
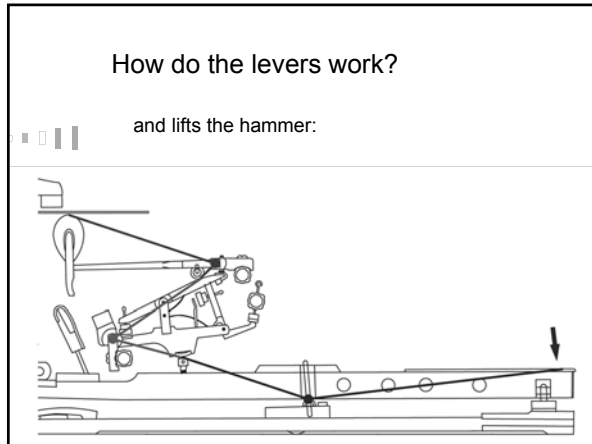
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How do the levers work?

and lifts the hammer:

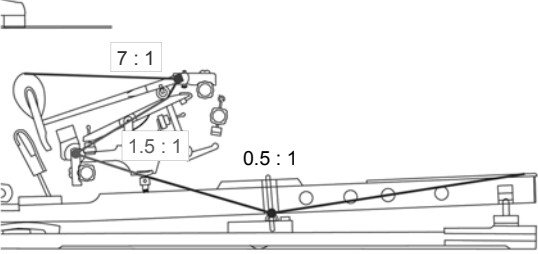


This diagram shows the piano action mechanism in its resting state. A key is shown at the bottom, connected to a hammer flange. Above the key is the hammer flange, which is connected to the hammer butt. The hammer butt is connected to the hammer flange, which is connected to the hammer butt. The hammer butt is connected to the hammer flange, which is connected to the hammer butt. The hammer butt is connected to the hammer flange, which is connected to the hammer butt.



How do the levers work?

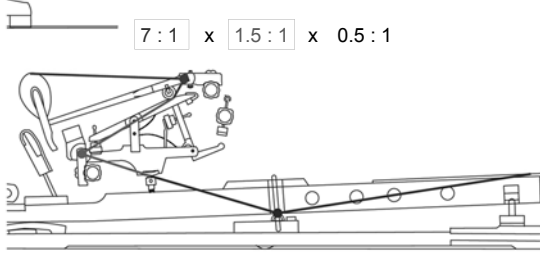
- The levers have different ratios, which can be measured geometrically:



The diagram shows a mechanical lever system with three stages of leverage. The first stage is labeled 7:1, the second 1.5:1, and the third 0.5:1. The diagram illustrates how these ratios are measured geometrically.

How do the levers work?

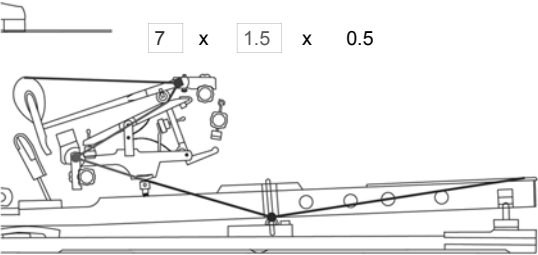
- By combining them:



The diagram shows the same mechanical lever system, but now with the combined ratio $7:1 \times 1.5:1 \times 0.5:1$ indicated above the diagram.

How do the levers work?

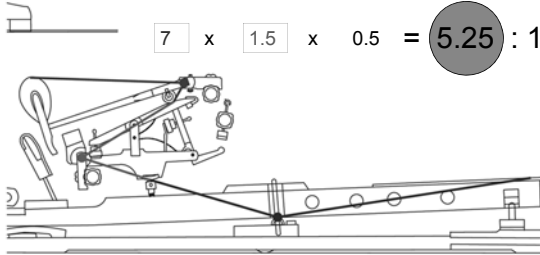
and reducing:



The diagram shows the mechanical lever system with the reduced ratio $7 \times 1.5 \times 0.5$ indicated above the diagram.

How do the levers work?

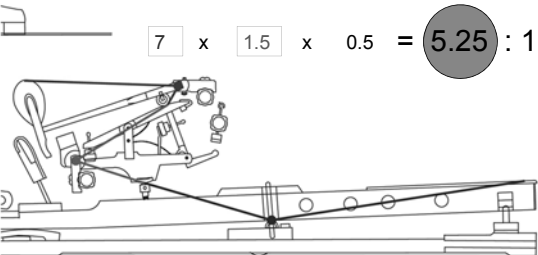
we can calculate the total geometric leverage ratio:



The diagram shows the mechanical lever system with the total geometric leverage ratio $7 \times 1.5 \times 0.5 = 5.25 : 1$ indicated above the diagram.

How do the levers work?

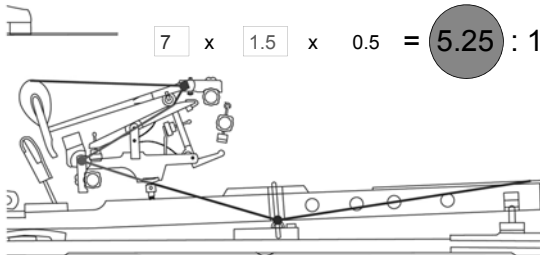
which approximates the ratio between finger force and hammer "weight", or ...



The diagram shows the mechanical lever system with the approximated ratio $7 \times 1.5 \times 0.5 = 5.25 : 1$ indicated above the diagram.

How do the levers work?

force leverage ratio.



The diagram shows the mechanical lever system with the force leverage ratio $7 \times 1.5 \times 0.5 = 5.25 : 1$ indicated above the diagram.

How do the levers work?

Force leverage ratio is higher at rest due to the angle between these two levers:

Force leverage = 5.60 : 1

How do the levers work?

... and decreases toward escapement as the angle gets reduced:

Force leverage = 5.10 : 1

Action as a single lever

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

Action as a single lever

... or a very long key with the fulcrum (axis of rotation) far off center:

fulcrum

Action as a single lever

... or a very long key with the fulcrum (axis of rotation) far off center:

Action as a single lever

... or a very long key with the fulcrum (axis of rotation) far off center:

Action as a single lever

... or a very long key with the fulcrum (axis of rotation) far off center:

The diagram shows a long, thin grey key pivoted on a triangular fulcrum. A lightbulb is attached to the left end, and a hammer head is at the right end. The fulcrum is positioned much closer to the hammer head than to the lightbulb. A horizontal line is drawn above the key, and a vertical dashed line marks the fulcrum's position. A small grey rectangle is on the left, and a larger white rectangle is on the right.

Action as a single lever

... or a very long key with the fulcrum (axis of rotation) far off center:

The diagram shows a long, thin grey key pivoted on a triangular fulcrum. A lightbulb is attached to the left end, and a hammer head is at the right end. The fulcrum is positioned much closer to the hammer head than to the lightbulb. A horizontal line is drawn above the key, and a vertical dashed line marks the fulcrum's position. A small grey rectangle is on the left, and a larger white rectangle is on the right.

Action as a single lever

By observing the weights and distances on either end:

The diagram shows a long, thin grey key pivoted on a triangular fulcrum. A lightbulb is attached to the left end, and a hammer head is at the right end. The fulcrum is positioned much closer to the hammer head than to the lightbulb. A horizontal line is drawn above the key, and a vertical dashed line marks the fulcrum's position. A small grey rectangle is on the left, and a larger white rectangle is on the right.

Action as a single lever

Our extra long key translates:

The diagram shows a long, thin grey key pivoted on a triangular fulcrum. A lightbulb is attached to the left end, and a hammer head is at the right end. The fulcrum is positioned much closer to the hammer head than to the lightbulb. A horizontal line is drawn above the key, and a vertical dashed line marks the fulcrum's position. A small grey rectangle is on the left, and a larger white rectangle is on the right.

Action as a single lever

Our extra long key translates:

short key stroke

The diagram shows a long, thin grey key pivoted on a triangular fulcrum. A lightbulb is attached to the left end, and a hammer head is at the right end. The fulcrum is positioned much closer to the hammer head than to the lightbulb. A horizontal line is drawn above the key, and a vertical dashed line marks the fulcrum's position. A small grey rectangle is on the left, and a larger white rectangle is on the right. A vertical double-headed arrow indicates a small displacement at the hammer head.

Action as a single lever

Our extra long key translates:

to longer hammer stroke

short key stroke

The diagram shows a long, thin grey key pivoted on a triangular fulcrum. A lightbulb is attached to the left end, and a hammer head is at the right end. The fulcrum is positioned much closer to the hammer head than to the lightbulb. A horizontal line is drawn above the key, and a vertical dashed line marks the fulcrum's position. A small grey rectangle is on the left, and a larger white rectangle is on the right. A vertical double-headed arrow indicates a small displacement at the hammer head, and another vertical double-headed arrow indicates a larger displacement at the lightbulb.

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?
Measuring strike weight (**SW**) on a scale

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?

- Leads cause the front of the key to be pulled down by gravity. That is the front weight (**FW**):

What makes the piano action heavy or light?

Measuring front weight (**FW**) on a scale

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**)! 10 grams during downstroke:

What makes the piano action heavy or light?

- Friction (F)! And 10 grams 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:

What makes the piano action heavy or light?

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

What makes the piano action heavy or light?

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

What makes the piano action heavy or light?

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

What makes the piano action heavy or light?

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

Diagram illustrating the forces on the piano action mechanism. A hammer is shown striking a key. The forces are: c. 10 grams (downward), Friction: 0 grams, DW 40g (downward), and UW 40g (downward).

What makes the piano action heavy or light?

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

Diagram illustrating the forces on the piano action mechanism. A hammer is shown striking a key. The forces are: c. 10 grams (downward) and BW 40 grams (downward).

What makes the piano action heavy or light?

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

Diagram illustrating the forces on the piano action mechanism. A hammer is shown striking a key. The forces are: c. 10 grams (downward) and BW 40 grams (downward).

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

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**):

Number line showing UW, BW, and DW values. The scale is from 0 to 50 g. UW is at 30 g, BW is at 40 g, and DW is at 50 g.

$$BW = (DW + UW) / 2$$

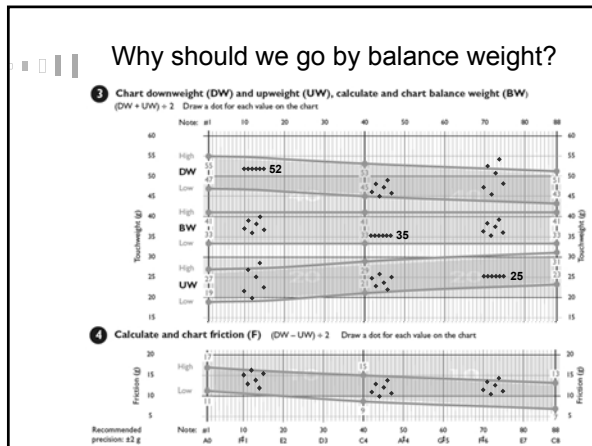
$$BW = (50 \text{ g} + 30 \text{ g}) / 2$$

$$BW = 80 \text{ g} / 2$$

$$BW = 40 \text{ g}$$

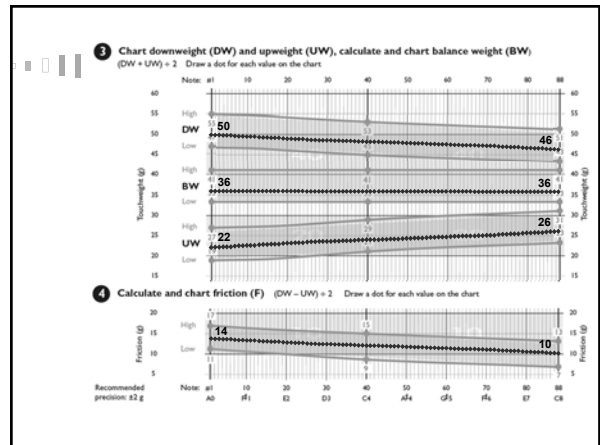
Even in the best grands, **Friction** varies by 2-4 g note to note. How does that affect touch if we aim for a smooth:

- DW
- BW
- UW?

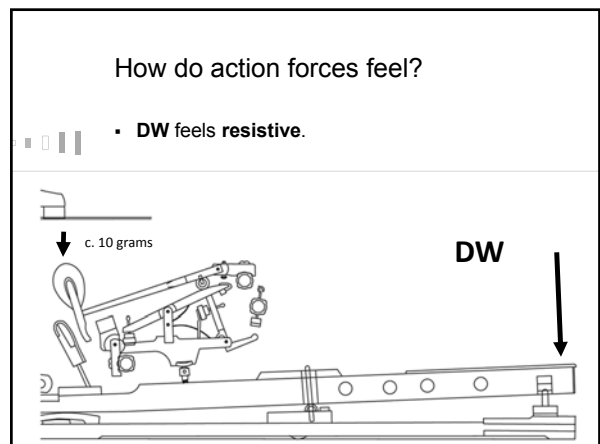


- Why should we go by balance weight?
- If DW is consistent, UW varies by **twice as much** as BW
 - If UW is consistent, DW varies by **twice as much** as BW
 - If BW is consistent, DW and UW vary by **same amount**

- 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



How Do Action Forces Feel?



How do action forces feel?

- UW feels repelling.

The diagram shows a piano action mechanism. A downward arrow on the left is labeled "c. 10 grams". An upward arrow on the right is labeled "UW".

How do action forces feel?

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

The diagram shows a piano action mechanism. A downward arrow on the left is labeled "c. 10 grams". A downward arrow on the right is labeled "High DW" with "55 grams+" below it.

How do action forces feel?

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

The diagram shows a piano action mechanism. A downward arrow on the left is labeled "c. 10 grams". An upward arrow on the right is labeled "High UW" with "35 grams+" below it.

How do action forces feel?

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

The diagram shows a piano action mechanism. A downward arrow on the left is labeled "c. 10 grams". A downward arrow on the right is labeled "Low DW" with "< 45 grams" below it.

How do action forces feel?

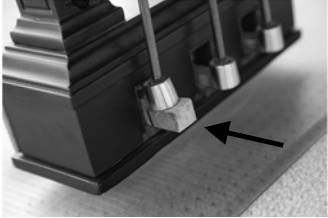
- Low UW feels sluggish, as if the action lags behind you. Repetition is impeded. Dancing keys?

The diagram shows a piano action mechanism. A downward arrow on the left is labeled "c. 10 grams". An upward arrow on the right is labeled "Low UW" with "< 15 grams" below it.

Measuring DW and UW

Prepare

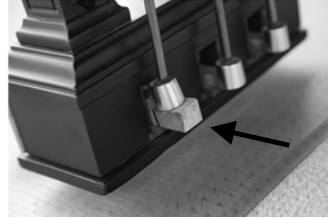
- First, **prop the pedal** up with a wedge



... 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)

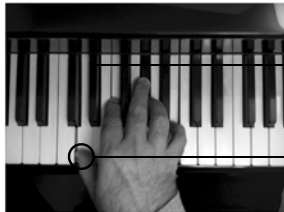
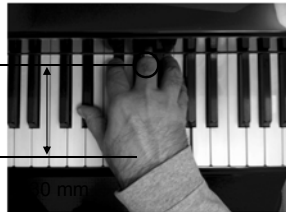
Place the weight so its center is $\frac{1}{2}$ " (13 mm) in from the edge of the key top



David Stanwood's Standard Measurement Position (SMP)

Measure Downweight (DW)

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

- 
- 

Measure Downweight (DW)

- In a 6' grand 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

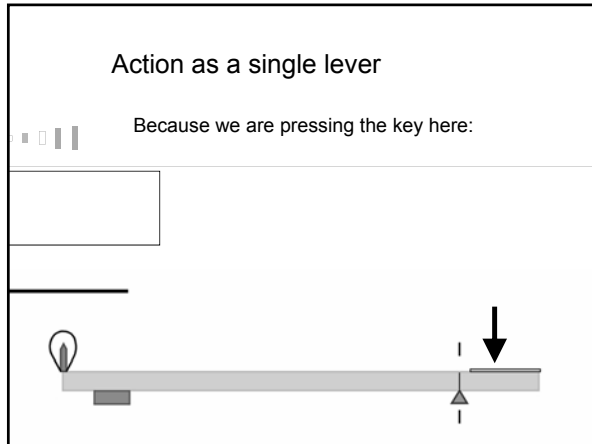
Measure Downweight (DW)

Why?

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

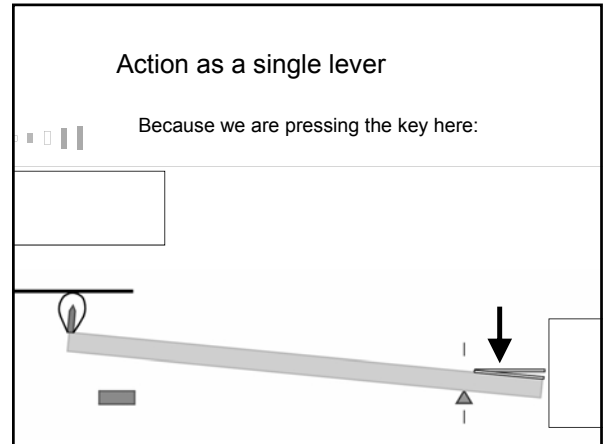
Action as a single lever

Because we are pressing the key here:



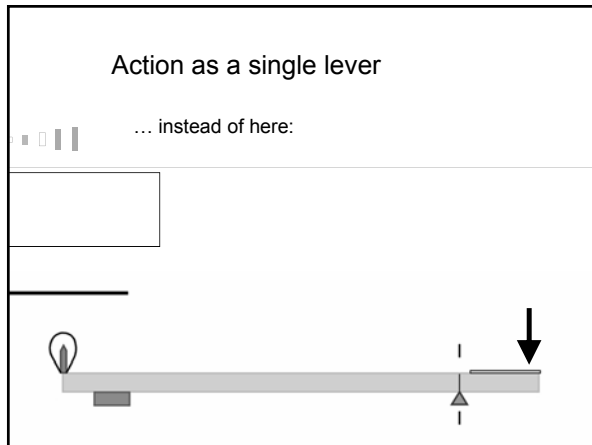
Action as a single lever

Because we are pressing the key here:



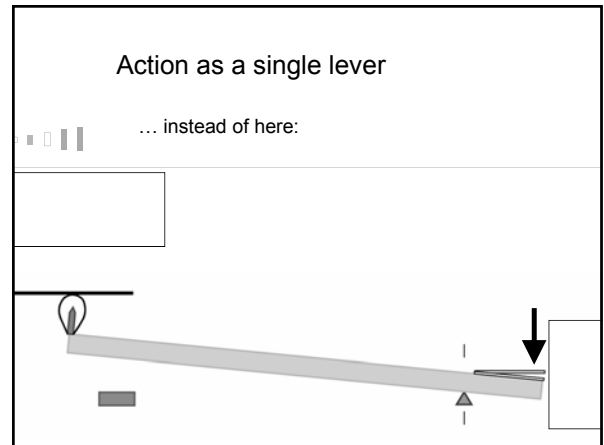
Action as a single lever

... instead of here:



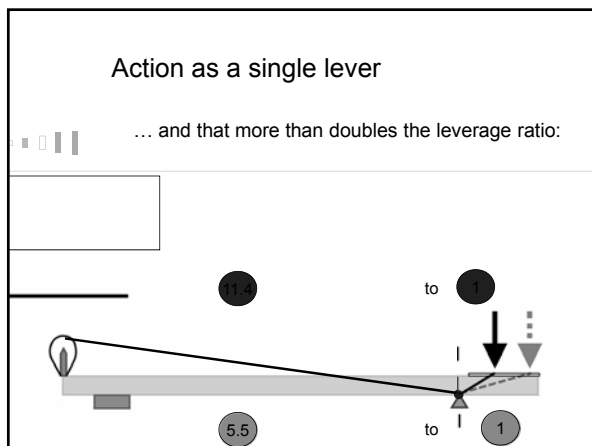
Action as a single lever

... instead of here:



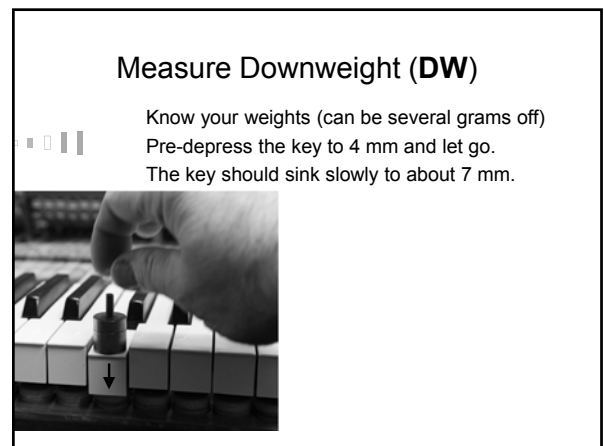
Action as a single lever

... and that more than doubles the leverage ratio:



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.



Measuring

- Sample measurements and calculations:

Note:	C1	C3	C5	C7
DW:	52 g			
UW:	22 g			
BW:	37 g			
F:	15 g			

Measuring

- Sample measurements and calculations:

Note:	C1	C3	C5	C7
DW:	52 g	50 g		
UW:	22 g	26 g		
BW:	37 g			
F:	15 g			

Measuring

- Sample measurements and calculations:

Note:	C1	C3	C5	C7
DW:	52 g	50 g		
UW:	22 g	26 g		
BW:	37 g	38 g		
F:	15 g	12 g		

Measuring

- Sample measurements and calculations:

Note:	C1	C3	C5	C7
DW:	52 g	50 g	47 g	
UW:	22 g	26 g	25 g	
BW:	37 g	38 g		
F:	15 g	12 g		

Measuring

- Sample measurements and calculations:

Note:	C1	C3	C5	C7
DW:	52 g	50 g	47 g	
UW:	22 g	26 g	25 g	
BW:	37 g	38 g	36 g	
F:	15 g	12 g	11 g	

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	
F:	15 g	12 g	11 g	

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

Calculating balance weight (BW)

$$\begin{aligned} (DW + UW) / 2 &= \\ (52 + 22) / 2 &= \\ 74 / 2 &= \\ 37 \text{ g} & \end{aligned}$$

Old Steinway standard: 35 g
(See Rudolf Dietz, *Steinway Regulation*, pp. 36-37)

Recommended: **38 g**
allows reducing **SW** by filing hammers

OK: 33 – 41 g

Calculating friction (F)

$$\begin{aligned} (DW - UW) / 2 &= \\ (52 - 22) / 2 &= \\ 30 / 2 &= \\ 15 \text{ g} & \end{aligned}$$

Recommended:

A0: 14 g (OK: 11 – 17 g)

C4: **12 g** (OK: 9 – 15 g)

C8: 10 g (OK: 7 – 13 g)

DW/UW matrix (for note C4)

DW:

	Low < 45 g	High > 53 g
Low < 21 g	<ul style="list-style-type: none"> •Light •Dynamics: either <i>p</i> of <i>f</i> •Poor repetition •Dancing keys 	<ul style="list-style-type: none"> •Resistive ("heavy") •Unresponsive •Sluggish •High friction
High > 29 g	<ul style="list-style-type: none"> •Flyaway •Nothing to bite into •Repels fingers •Low friction 	<ul style="list-style-type: none"> •Heavy •Hard to play <i>ppp</i> •Responsive •Good repetition

UW:

DW/UW matrix (for note C4)

DW:

	Low < 45 g	High > 53 g
Low < 21 g	<ul style="list-style-type: none"> •Light •Dynamics: either <i>p</i> of <i>f</i> •Poor repetition •Dancing keys 	<ul style="list-style-type: none"> •Resistive ("heavy") •Unresponsive •Sluggish •High friction
High > 29 g	<ul style="list-style-type: none"> •Flyaway •Nothing to bite into •Repels fingers •Low friction 	<ul style="list-style-type: none"> •Heavy •Hard to play <i>ppp</i> •Responsive •Good repetition

UW:

↔

DW/UW matrix (for note C4)

DW:

	Low < 45 g	High > 53 g
Low < 21 g	<ul style="list-style-type: none"> •Light •Dynamics: either <i>p</i> of <i>f</i> •Poor repetition •Dancing keys 	<ul style="list-style-type: none"> •Resistive ("heavy") •Unresponsive •Sluggish •High friction
High > 29 g	<ul style="list-style-type: none"> •Flyaway •Nothing to bite into •Repels fingers •Low friction 	<ul style="list-style-type: none"> •Heavy •Hard to play <i>ppp</i> •Responsive •Good repetition

UW:

↔ leads

DW/UW matrix (for note C4)

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How to Rebalance the Action?

- ### How to rebalance the action?
- Alter strike weight (SW) (changes tone, inertia):
 - File hammers
 - Thin/taper the hammers
 - Replace hammers (lighter/heavier)
 - Add clips
 - Install lead wire
 - Change the action leverage ratio (R) (changes key dip, inertia)
 - Add or remove key leads (alter FW) (no significant change in inertia)
 - TouchRail, wippen ("turbo") springs, magnets (no change in inertia)
- big topics for another time!



- ### Limits of static 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
- Always consider *all* aspects of touch adjustment, not just static balancing

What Are We Measuring?

What are we measuring?

Because the action is laid horizontally, we can measure forces as weights.

To simplify, we treat rotational forces (torque) as linear, vertical forces

What are we measuring?

In this example, the action has a leverage ratio of 5.5 : 1:

What are we measuring?

On the back end, the key lifts the **SW** (hammer strike weight):

What are we measuring?

On the back end, the key lifts the **SW** (hammer strike weight):

What are we measuring?

To balance the SW, the weight needed on the other end is 55 g:

What are we measuring?

The back segment also carries the **WW** (wippen weight):

What are we measuring?

The back segment also carries the **WW** (wippen weight):

SW Stack
10.0
8.8-10.1
1

Wippen radius weight (g): 20.0

20.0 g

What are we measuring?

Measuring the **WW** (wippen weight):

Photo by Jude Reveley, RPT

What are we measuring?

WW (wippen weight) acts on the key with the key leverage ratio of approx. 0.5 : 1:

SW Stack
10.0
8.8-10.1
1

Wippen radius weight (g): 20.0

Key ratio (mm): 0.50

Target Leverage: 0.25
5.50
12.40
0

10 g

20.0 g

$x15.50 = 55\text{ g}$

What are we measuring?

WW (wippen weight) acts on the key with the key leverage ratio of approx. 0.5 : 1:

0.5 : 1

What are we measuring?

... adding 10 grams to the front end:

SW Stack
10.0
8.8-10.1
1

Wippen radius weight (g): 20.0

Key ratio (mm): 0.50

Target Leverage: 0.25
5.50
12.40
0

10 g

20.0 g

$x15.50 = 55\text{ g}$

$20.0\text{ g} \times 0.50 = 10\text{ g}$

What are we measuring?

Together, the two weights are:

SW Stack
10.0
8.8-10.1
1

Wippen radius weight (g): 20.0

Key ratio (mm): 0.50

Target Leverage: 0.25
5.50
12.40
0

10 g

20.0 g

$x15.50 = 55\text{ g}$

$+ 10\text{ g}$

What are we measuring?
Together, the two weights are 65 g:

SW 0.5g
10.0
55.0
1

Wippen radius weight (g): 20.0
Key ratio (mm): 0.50
Target Leverage/
Leverage 5.50
0.25
5.50
12.50
0

= 65 g

What are we measuring?
Since we want the **BW** (balance weight) to be 35 g:

SW 0.5g
10.0
25.0
1

Wippen radius weight (g): 20.0
Key ratio (mm): 0.50
Target Leverage/
Leverage 5.50
0.25
5.50
12.50
0

BW Balancezeit 3.0g
35
34.30
0

= 65 g

What are we measuring?
(because with **Friction** of 12 g, **DW** = 47 g):

SW 0.5g
10.0
37.0
1

Wippen radius weight (g): 20.0
Key ratio (mm): 0.50
Target Leverage/
Leverage 5.50
0.25
5.50
12.50
0

F Friction 1.5g
12
11.10
0

DW Downweight grams
47
45.50
0

= 65 g

What are we measuring?
(and **UW** = 23 g):

SW 0.5g
10.0
13.0
1

Wippen radius weight (g): 20.0
Key ratio (mm): 0.50
Target Leverage/
Leverage 5.50
0.25
5.50
12.50
0

F Friction 1.5g
12
11.10
0

UW Upweight grams
23
21.30
0

= 65 g

What are we measuring?
we need to install leads:

SW 0.5g
10.0
55.0
1

Wippen radius weight (g): 20.0
Key ratio (mm): 0.50
Target Leverage/
Leverage 5.50
0.25
5.50
12.50
0

= 65 g

What are we measuring?
... which will increase the **FW** (front weight) of the key to 30 g:

SW 0.5g
10.0
25.0
1

Wippen radius weight (g): 20.0
Key ratio (mm): 0.50
Target Leverage/
Leverage 5.50
0.25
5.50
12.50
0

FW Frontzeit 3.0g
30
28.30
1

= 65 g

What are we measuring?
 ... so that the sum of **BW** and **FW** is 65 g:

SW: 10.0g
 Wippen radius weight (g): 20.0
 Key ratio (mm): 0.50
 Target Leverage: 0.25
 Balance weight (BW): 35g
 Frontlet (FW): 30g
 = 65 g

What are we measuring?
 And that is David Stanwood's equation of balance:
 $BW + FW = (KR \times WW) + (Leverage \times SW)$

SW: 10.0g
 Wippen radius weight (g): 20.0
 Key ratio (mm): 0.50
 Target Leverage: 0.25
 Balance weight (BW): 35g
 Frontlet (FW): 30g
 = 65 g

What are we measuring?
 Weight balance model (without key leads)

- SW: Hammer strike weight
- SR: Shank weight ratio
- WW: Wippen radius weight
- WR: Wippen weight ratio
- WSW: Wippen stack weight
- KR: Key weight ratio
- BW: Balance weight
- DW: downweight
- F: Friction

What are we measuring?
 Weight balance model (with key leads)

- SW: Hammer strike weight
- SR: Shank weight ratio
- WW: Wippen radius weight
- WR: Wippen weight ratio
- WSW: Wippen stack weight
- KR: Key weight ratio
- BW: Balance weight
- DW: downweight
- F: Friction

Where to go next?

- Free Practical Touch Analysis calculator


<http://pianosinsideout.com/Bonus.html>

Practical Touch Analysis calculator

- Weights, resistance, distances, and leads:

Practical Touch Analysis calculator

- Effect of dampers on touch:



Up Force
DamperDifference
grams

34 ▲
27.42 ▼

DAMPER

20 ▲
21.39 ▼

Damper Lift
DamperLift
4.5 g

30
24.38
0

Underlever Lift
UnderleverLift
3.0 g

20
16.38
0

DL Friction
DamperDLFriction
2.0 g

4.0
3.4
0

UL Friction
UnderleverULFriction
1.5 g

2.7
2.4
0

BW with Damper
BassweightDamper
3.0 g

65
52.42
0

DW with Damper

70
65.78

UW with Damper

40
34.50

Damper Divergence:

0

Practical Touch Analysis calculator

- Hammer weight estimates:

This tab allows you to estimate the weight of several reference hammers, groups of hammers, or an entire set based on data on the Weight & Distance Calc tab. Hammer weight estimates allow matching replacement hammers to the original set more closely than ordering by pound weight or size alone. Contact your supplier to find out what information they require.

	Unfinished Weight grams	Finished HW + Shank Weight
Hammer #33:	9.4 8.918	10.2 9.818
Hammer #27:	9.0 8.518	10.0 9.618
Hammer #21:	10.2 9.718	10.8 10.418
Hammer #1:	11.0 10.518	11.4 11.018
Bottom 10 Hammers Average Weight:	10.0 9.520	10.0 9.520
Entire Set (96 Hammers) (including a 22 g wrapper)	830 792.00	830 792.00

Hammer numbers assume the final, installed position. For example, if the piano has 26 notes in the bass and a set of new hammers contains 22 bass hammers, the lowest bass hammer will be stamped #33 but will be installed as #27. In this case the estimate on the list for hammer #27 applies to the hammer stamped #33.

Unfinished weight is the weight of a hammer with covered or notched tail that hasn't been drilled, shaped, or tapered. Unfinished weight calculations assume that drilling, shaping and tapering the tail of an unfinished hammer will reduce its weight by about 1.2 g.

HW estimates assume that the hammer with a shaped and tapered tail (below the left) is mounted on a shank with a radius weight of 1.6 g.

Weight estimates are based on average weight progressions in Stanswood's (note weight) series. (see <http://www.stanswoodpiano.com/PTC/Mach000.pdf>)

Weight estimates for the entire set assume that there are 96 hammers in the set, that the weight distribution within the set is close to Stanswood's (note weight) series, and that the set is supplied in a wrapper weighing 22 grams.

Where to Go Next

- In US: **David Stanwood:**
Training, certification (<http://www.stanwoodpiano.com/>)
- In Europe: **PTDAE**
Precision Touch Design Academy Europe
(<http://ptdae.com>)
- Stay tuned for **Practical Touch Adjustment**
system (pianosinsideout.com/Bonus)

Thank you!

www.pianosinsideout.com/Classes