The Grand Balancing Act

"Action Weigh-Off Simplified"

Act I

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PTG Annual Convention

Tucson, AZ

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Class Content – Act I

- Downweight, Upweight and Balance Weight concepts.
- Using Split Weights to measure Upweight & Downweight to Calculate Friction & Balance Weight.
- "The Split-Weight (Balance Weight) Measuring Method" developed by Steve Schell, RPT (following David Stanwood's Balance Weight concepts) to efficiently & accurately weigh off a grand action.
- Q & A –

Class Content – Act II

- Diagnosing the state of a grand action using the “The Split-Weight Balance Weight Measuring Method”.
- Simple B.S. Geometry 101: How To Analyze The Condition of A Grand Action – Create A ‘road map’ that will lead to improved, consistent and superior touch weight.
- Q & A –

Action Weigh-Off Challenges

Action Weigh-off Challenges

The ”touch” of this action is too heavy or too light…Where Do You Begin???

Is it a focus on Downweight or Upweight? What’s the ”number” you should use?

Trusted manufacturers and/or colleagues have different standards so you are confused?

Action Weigh-off Challenges

It’s cumbersome & time consuming to make Downweight and Upweight measurements for calculating friction.

Frustration from the effects of changing friction when measuring Downweight or Upweight note-to-note.

Target Weigh-Off #’s requires excessive leads which creates inertia problems….Now What???

Needed Understanding to Answer These Questions

Touch & Weigh-Off is affected by:

1) Action leverages (Ratio)
2) The weight of action parts (Primarily Strike Weight & Inertia)
3) Key Leading: How & Where (Front Weight & Inertia)
4) Friction

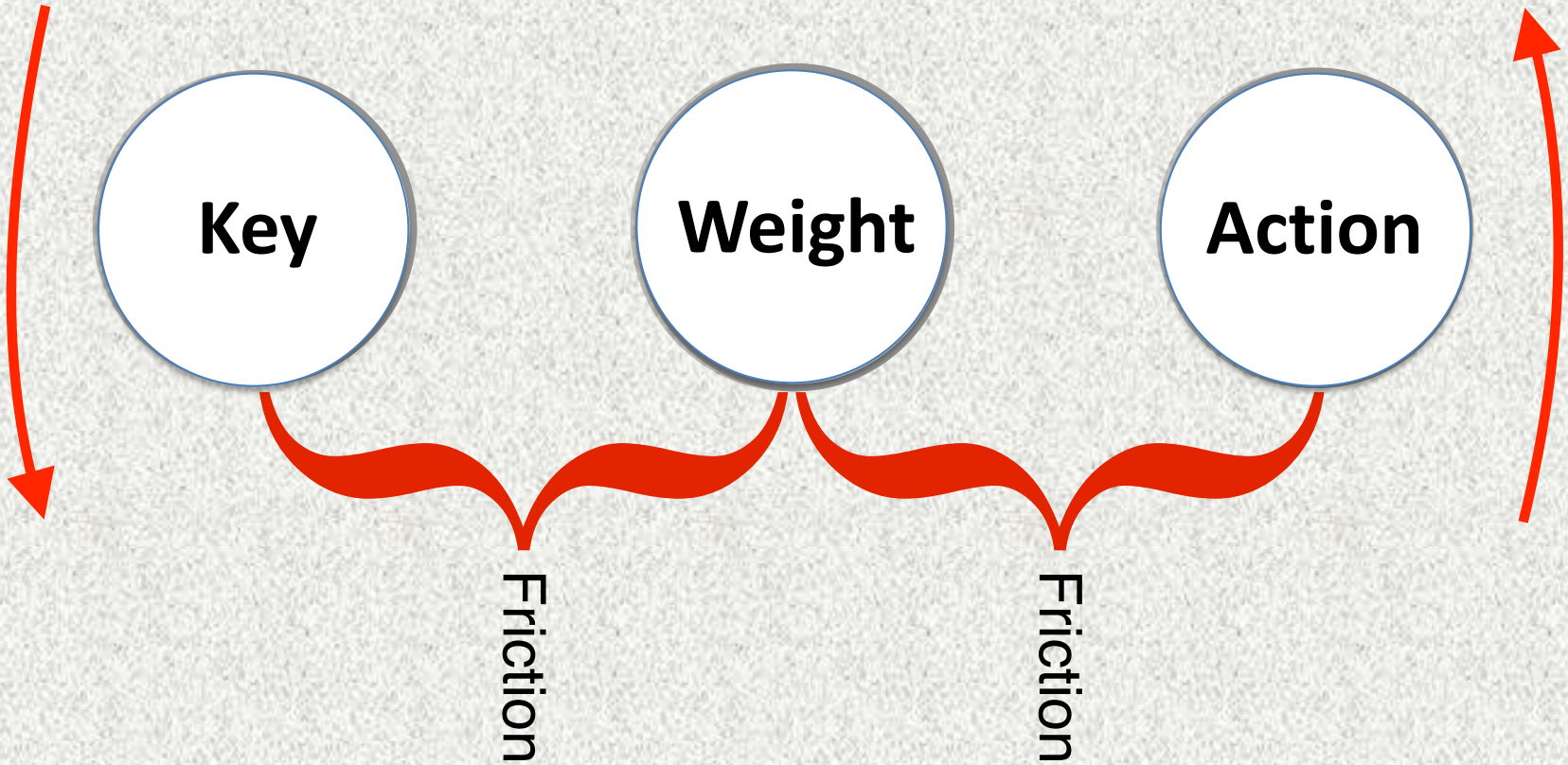
What is **Downweight?**

The resistance due to the *weight (mass)* of the hammer and other parts acting through the action levers, and…

The resistance due to *friction* (in action centers and between rubbing parts like capstan & wippen felt, knuckle & rep. lever, key pins & key bushings).

Downweight = Weight + Friction,
or D = Wt. + F." (Bill Spurlock 2006)

(Measured)
Downweight
= Wt + F



What is Weight?

What is **Upweight?**

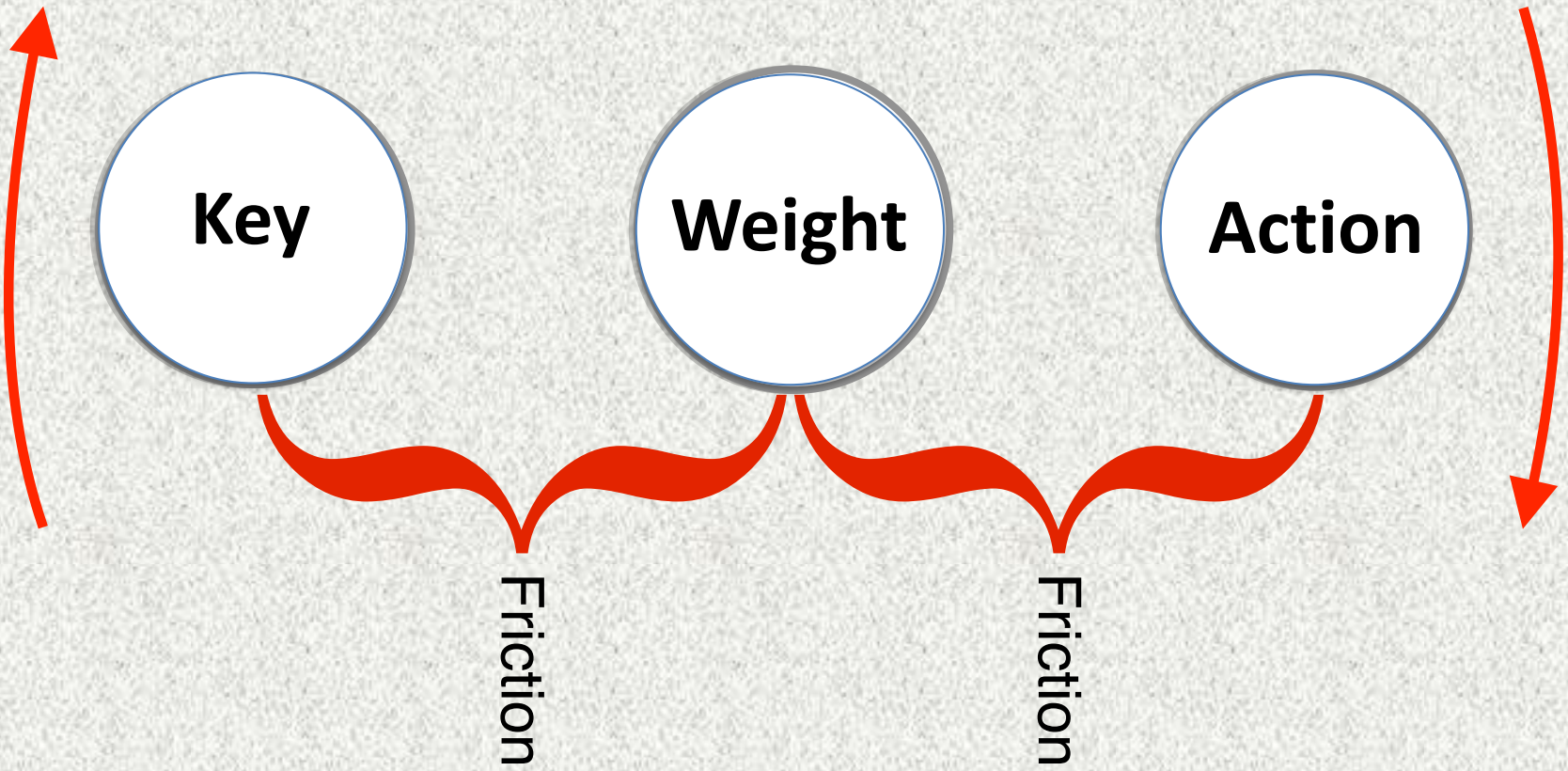
The force provided by the weight (mass) of the action parts trying to return to rest…

Minus the resistance to movement due to friction.

Upweight = Weight - Friction, or
U = Wt. - F

(Bill Spurlock 2006)

(Measured)
Upweight
= Wt - F



What is Weight?

Touch Weight Concepts

Combining these two equations to eliminate Wt. gives the equation:

(Downweight - Upweight) ÷ 2

= Friction,

(Bill Spurlock 2006)

How Much Downweight or Upweight?

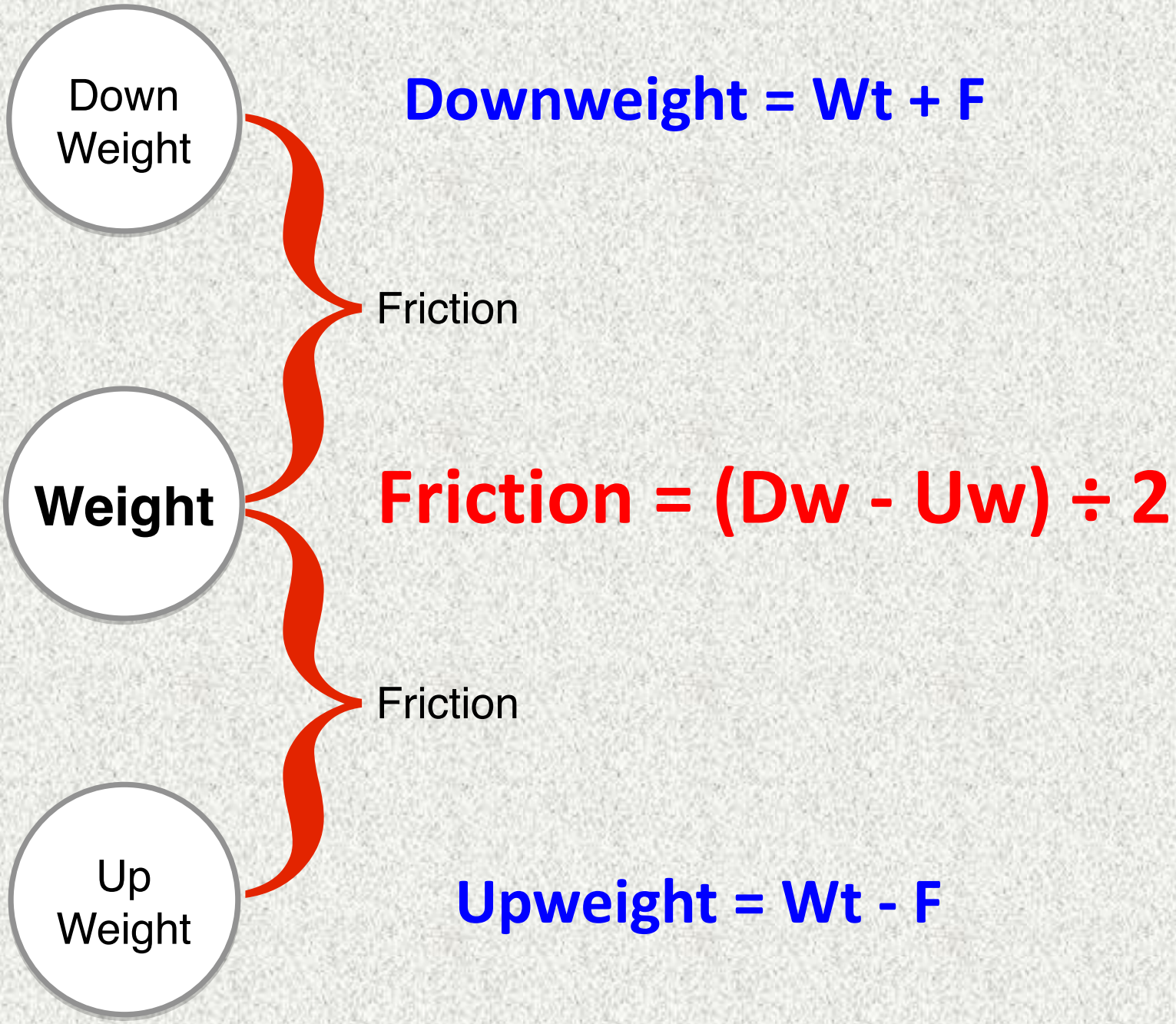
(Bill Spurlock 2006)

Downweight?

- “Downweight averages around 50 to 60 grams for most modern grand actions in good condition. Leads are inserted into the front halves of the keys during manufacture to overcome the weight of the hammers and other action parts and calibrate the downweight.”

Upweight?

- “20 grams is usually cited as a minimum upweight for good repetition, although this figure leaves little safety factor; if action pinning tightens up, knuckles become flattened, or as hammers become lighter due to filing, upweight (and key return speed) will decrease.”


Down Weight
Friction
Weight
Friction
Up Weight
Downweight = Wt + F
Friction = (Dw - Uw) ÷ 2
Upweight = Wt - F

Recommended Key Weigh Off Specifications

Grands

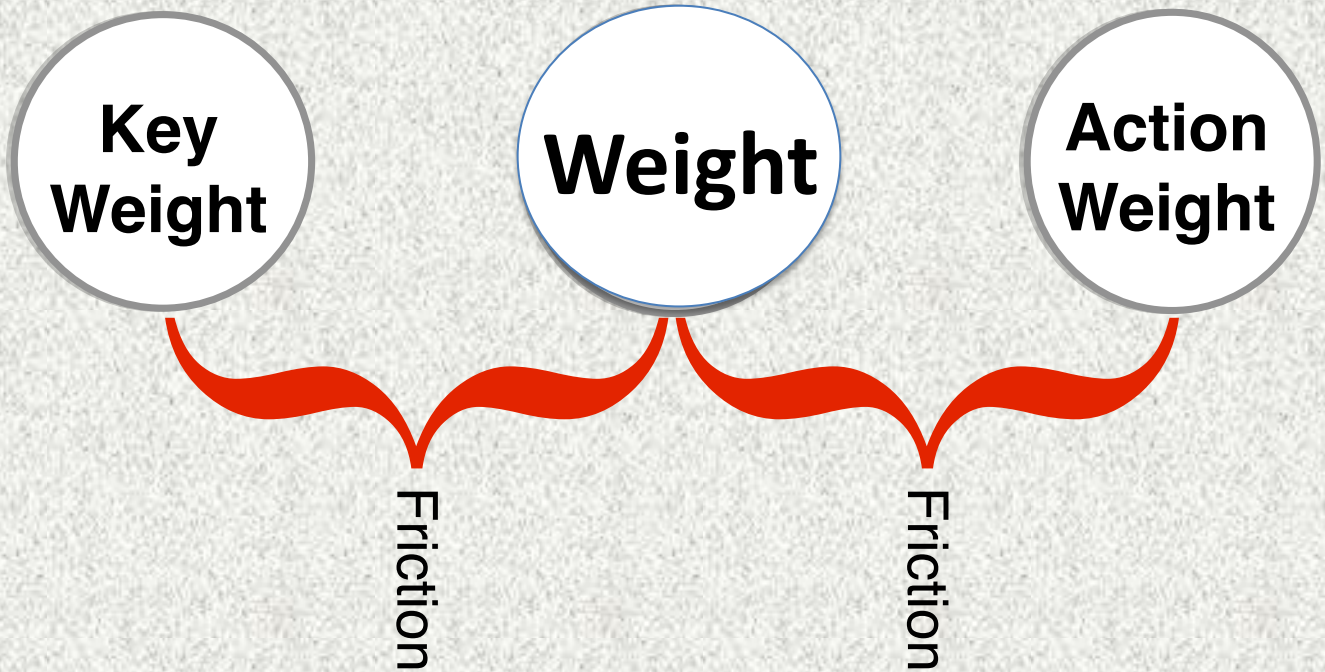
	Note #	Down Weight	Up Weight
S M L	1–26	50 GM	
	27–54	49 GM	20GM (+ Any Amount) (– 2 Grams)
	55–71	48 GM	
	72–88	47 GM	
B & D	1–16	51 GM	
	17–32	50 GM	
	33–45	49 GM	20GM (+ Any Amount) (– 2 Grams)
	46–61	48 GM	
	62–75	47 GM	
	76–88	46 GM	

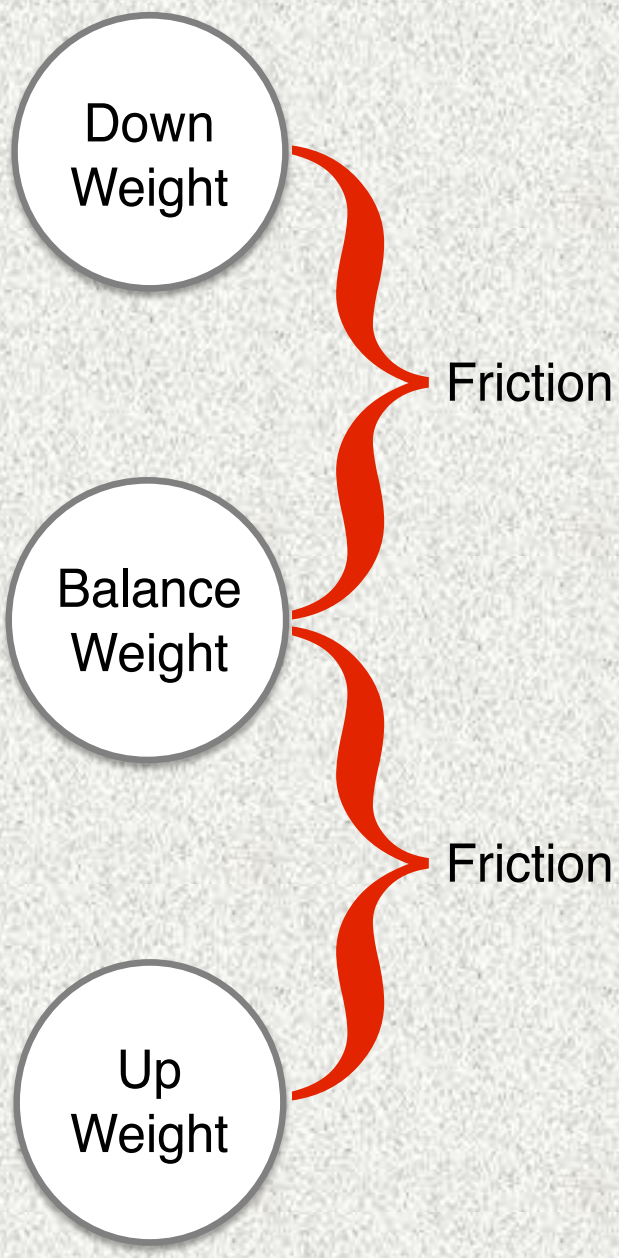
Verticals

All	1–88	55 GM	20GM (+ Any Amount) (– 2 Grams)

What is Weight?

"Weight": "The Point Halfway Between Measured Upweight and Downweight"





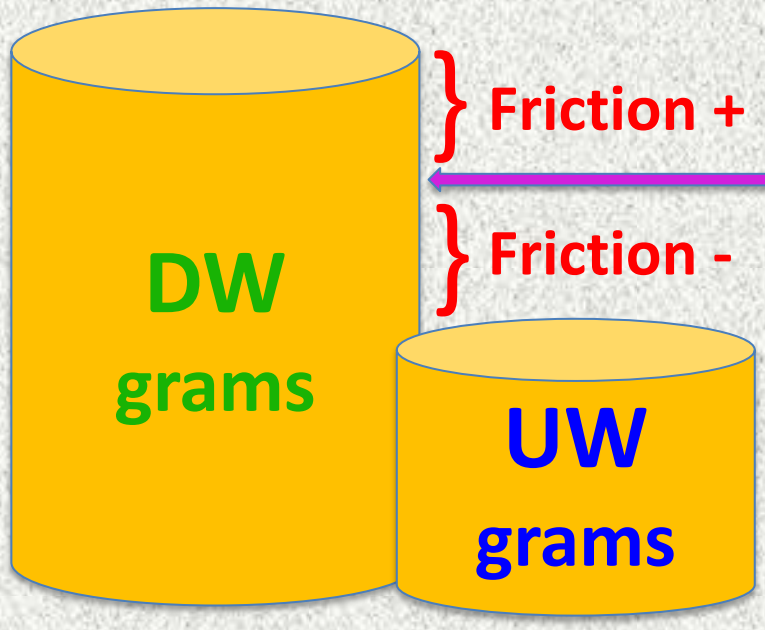
What Is Balance Weight?

Explanation of Balance Weight

David Stanwood's original articles in the PTG Journal & www.stanwoodpiano.com

1) Stanwood Action; A New Action System For The Grand Piano [October 1990]
2) Mastering Friction With The Balance Weight System [November 1990]
3) www.stanwoodpiano.com > Piano Technicians Resource Page

What/Where Is The Balance Weight?



BW = DW - F

The Balance Weight

BW = UW + F

F = (DW - UW) ÷ 2

BW = (DW + UW) ÷ 2

2 Essential Equations – David Stanwood PTJ 11/1990

“The Balance Weight value of a key/action assembly is the mid-point between Upweight and Downweight.”

David Stanwood PTJ 11/1990

"Understanding and employing Balance Weight as the standard for establishing the static touch weight of the action is not simply one method, it is the essential and most efficient method."

David Stanwood PTJ 11/1990

“Keys with uniform balance weight will have more uniform upweight and downweight values than if balance weight were allowed to vary.”

David Stanwood PTJ 11/1990

"We cannot measure balance weight directly, because it is impossible to eliminate all action friction. We can, however, use both upweight and downweight to calculate the balance weight as well as the friction."

David Stanwood PTJ 11/1990

"Theoretically, if we could eliminate all action friction, there would be no difference between upweight and downweight.

The touch weight would then be a single point halfway between the measured upweight and downweight.

I call this point the balance weight."

David Stanwood PTJ 11/1990

"Balance Weight value remains unaffected by friction, whereas upweight and downweight change daily and seasonally with friction.

Therefore, balance weight is the logical point of reference when balancing keys."

David Stanwood PTJ 11/1990

Touch Weight Concepts

"Increasing friction causes the Downweight to increase and the Upweight to decrease by equal amounts and vice versa,

decreasing friction causes the Downweight to decrease and Upweight to increase by equal amounts."

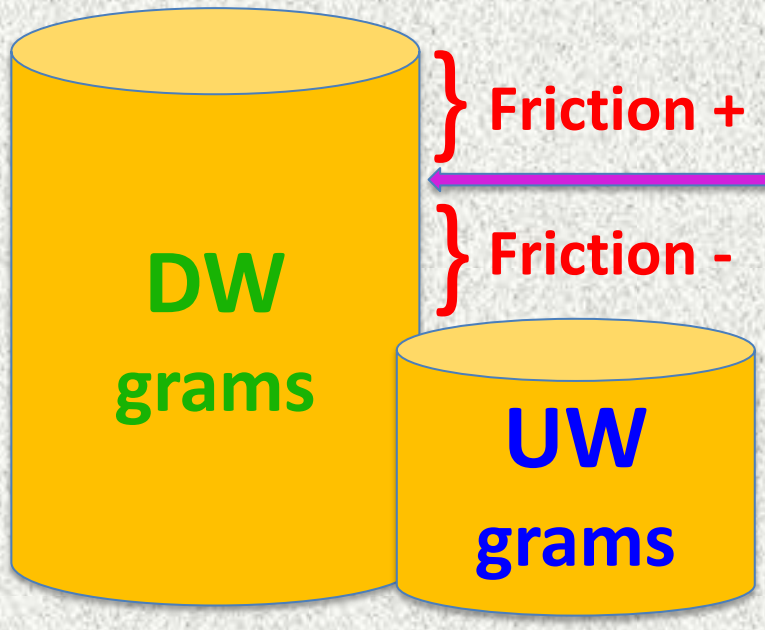
David Stanwood PTG Journal October 1990

Essential Concepts

A Change +/- In Front Weight or Strike Weight Changes Balance Weight

A Change In Friction Does Not Change Balance Weight

What/Where Is The Balance Weight?



BW = DW - F

The Balance Weight

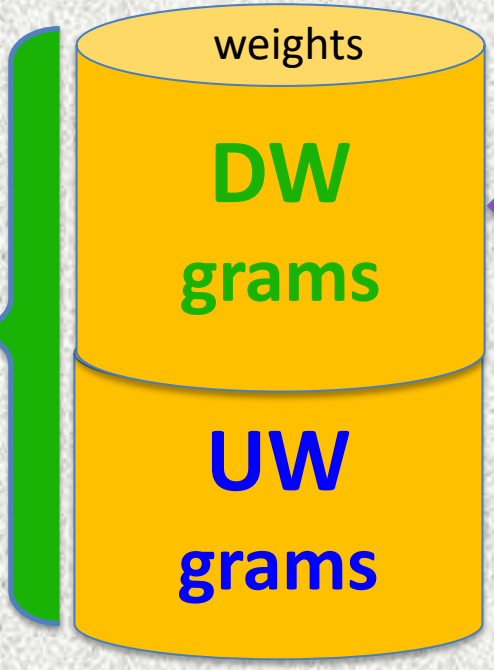
BW = UW + F

F = (DW - UW) ÷ 2

BW = (DW + UW) ÷ 2

2 Essential Equations – David Stanwood PTJ 11/1990

A Single Weight Stack Instead of 2 Separate Weights For Measuring DW & UW



Down Weight

Friction

Friction

BW = DW - F

The Balance Weight

BW = UW + F

Up Weight

DW = BW + F

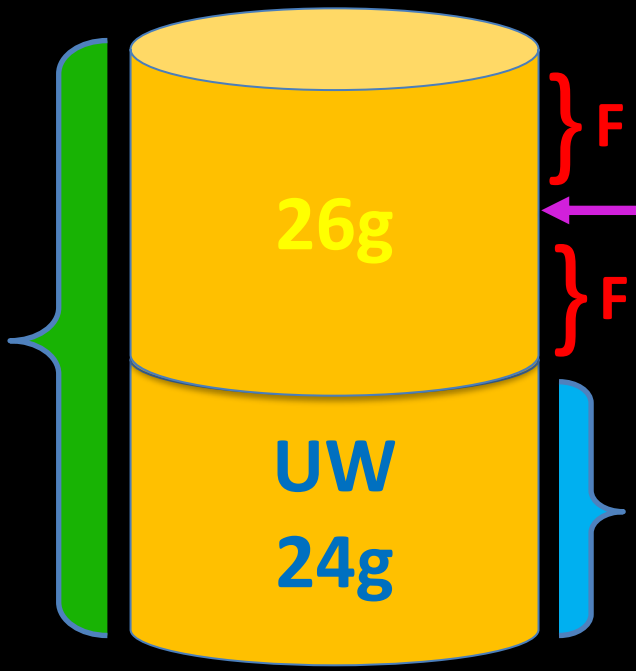
F = (DW - UW) ÷ 2

UW = BW – F

BW = (DW + UW) ÷ 2

What Is The Friction & Balance Weight?

The Key Is Balanced When The "Slow" Key/Action Motion From The Total "Stack" Weight vs. Upweight Is Even/Equal In Both Directions



Down Weight 50g

Up Weight

BW = DW - F

Balance Weight 37g

BW = UW + F

DW = BW + F

UW = BW – F

F = (DW – UW) ÷ 2

BW = (DW + UW) ÷ 2

Essential Equations For The Split Weight Measuring System

Friction =

Top weight ÷ 2

Balance Weight =

Upweight + Friction (½ top weight)

Bruce Stevens 7/10/19

What/Where Is The Balance Weight?

(The "Slow" Key/Action Motion From Total "Stack" Weight vs. Up Weight Is Equal/Even In Both Directions)

Then Apply Top Weight To Match Motion Of UW

Friction

Friction

The Balance Weight

Up Weight

Measure UW First

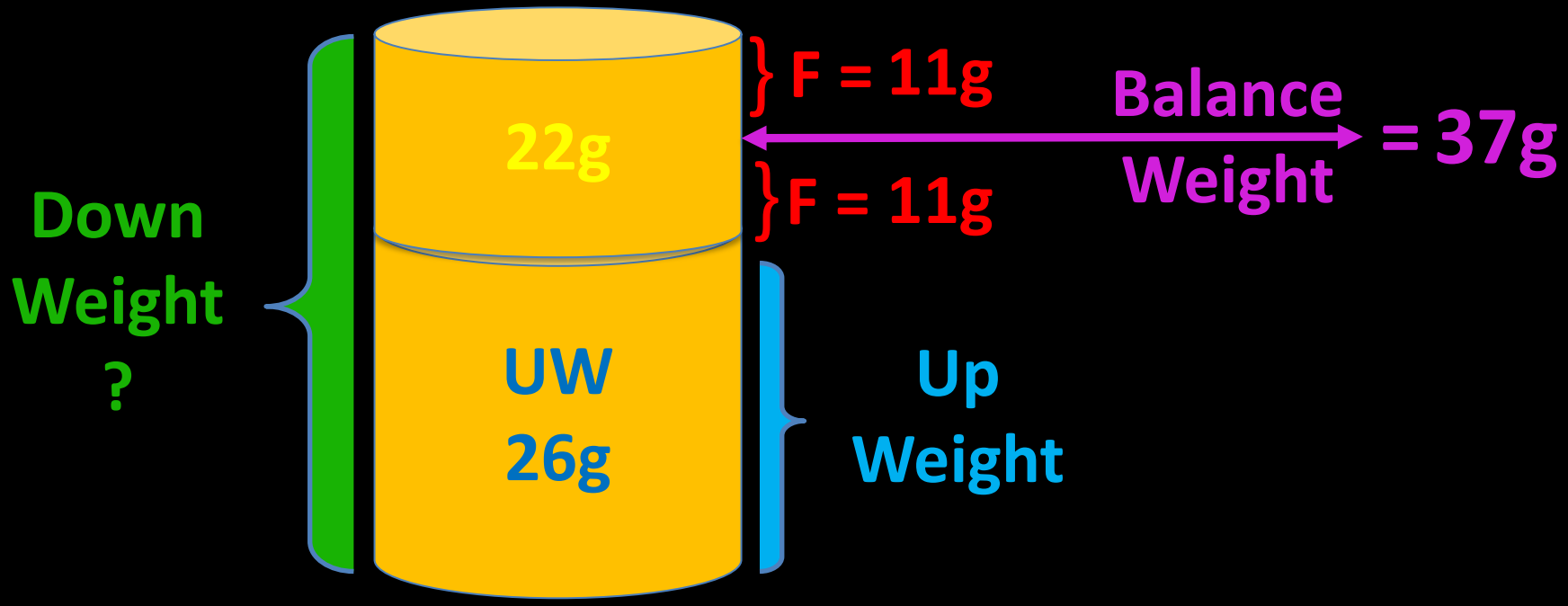
F = Top Weight ÷ 2

BW = UW + F

2 Essential Equations To Calculate Balance Weight

What Is The Friction & Balance Weight?

The Key Is Balanced When The "Slow" Key/Action Motion From The Total "Stack" Weight vs. Upweight Is Even/Equal In Both Directions



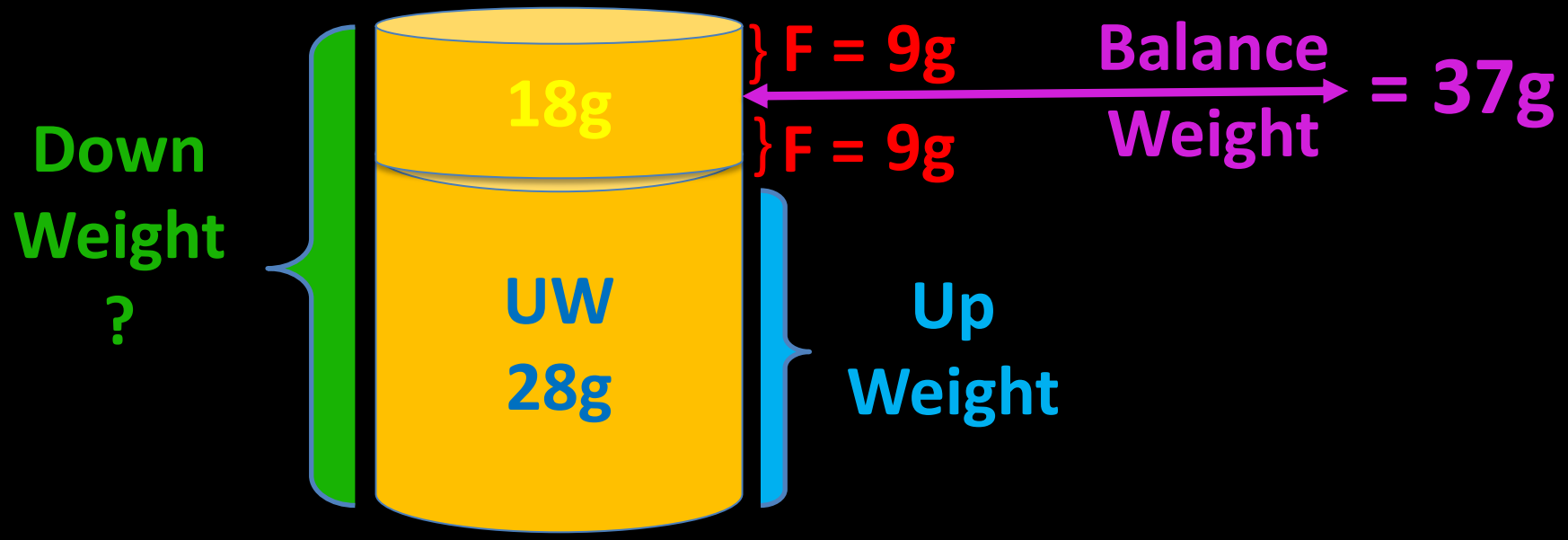
F = Top Weight ÷ 2

BW = UW + F

2 Essential Equations To Calculate Balance Weight

What Is The Friction & Balance Weight?

The Key Is Balanced When The "Slow" Key/Action Motion From The Total "Stack" Weight vs. Upweight Is Even/Equal In Both Directions



F = Top Weight ÷ 2

BW = UW + F

2 Essential Equations To Calculate Balance Weight

Essential Equations For The Split Weight Measuring System

Friction =

Top weight ÷ 2

Balance Weight =

Upweight + Friction (½ top weight)

Bruce Stevens 7/10/19

Problems & Issues With Downweight Target or Upweight Target Weigh-Off

Why are traditional weigh-off methods targeting downweight and upweight measurements inadequate?

- Favoring a **Downweight** target causes **upweight** to change 2 grams for every 1 gram change in friction note-to-note.
- Favoring an **Upweight** target causes **downweight** to change 2 grams for every 1 gram change in friction note-to-note.
- It creates inconsistent Balance Weight for every 1 gram change in friction note-to-note.

- Technician likely spends excessive amounts of time chasing down friction issues before any weigh-off begins.
- Once friction is “corrected” as best as possible, weigh-off must take place ASAP.
- End result is still uneven Balance Weight.

- The addition or subtraction of lead in the weigh-off process is dictated by friction.
- If Friction is not carefully regulated before the weigh-off begins, the amount of lead in the key will significantly vary note-to-note.
- End result is still uneven Balance Weight.

Stepped Down Weight Target

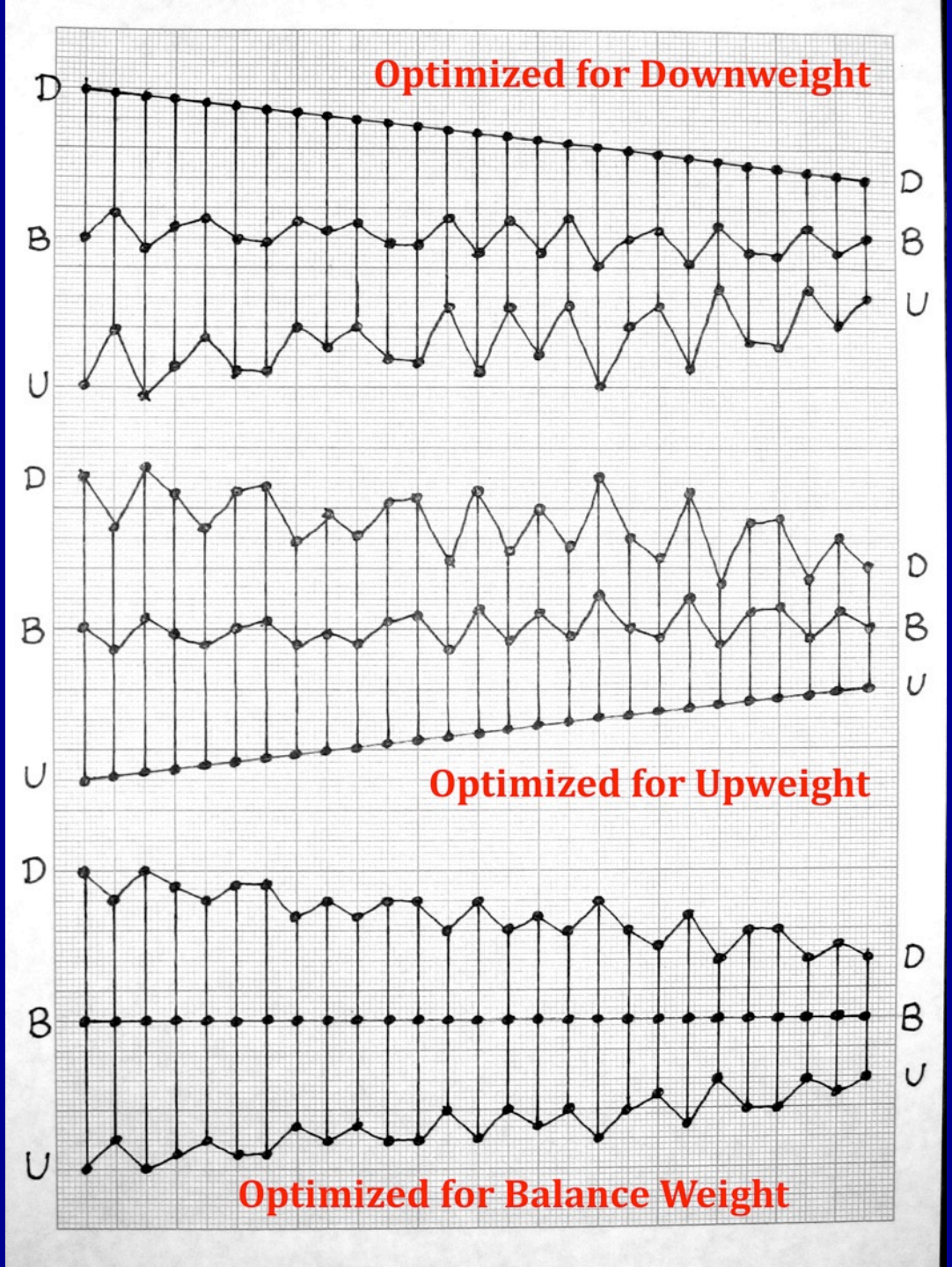
Downweight	**52**	**52**	**52**	**50**	**50**	**50**	**48**	**48**	**48**
Friction	16	15	14	13	12	11	10	9	8
Upweight	**20**	**22**	**24**	**24**	**26**	**28**	**28**	**30**	**32**
Balance Weight	36	37	38	37	38	39	38	39	40

Stepped Upweight Target

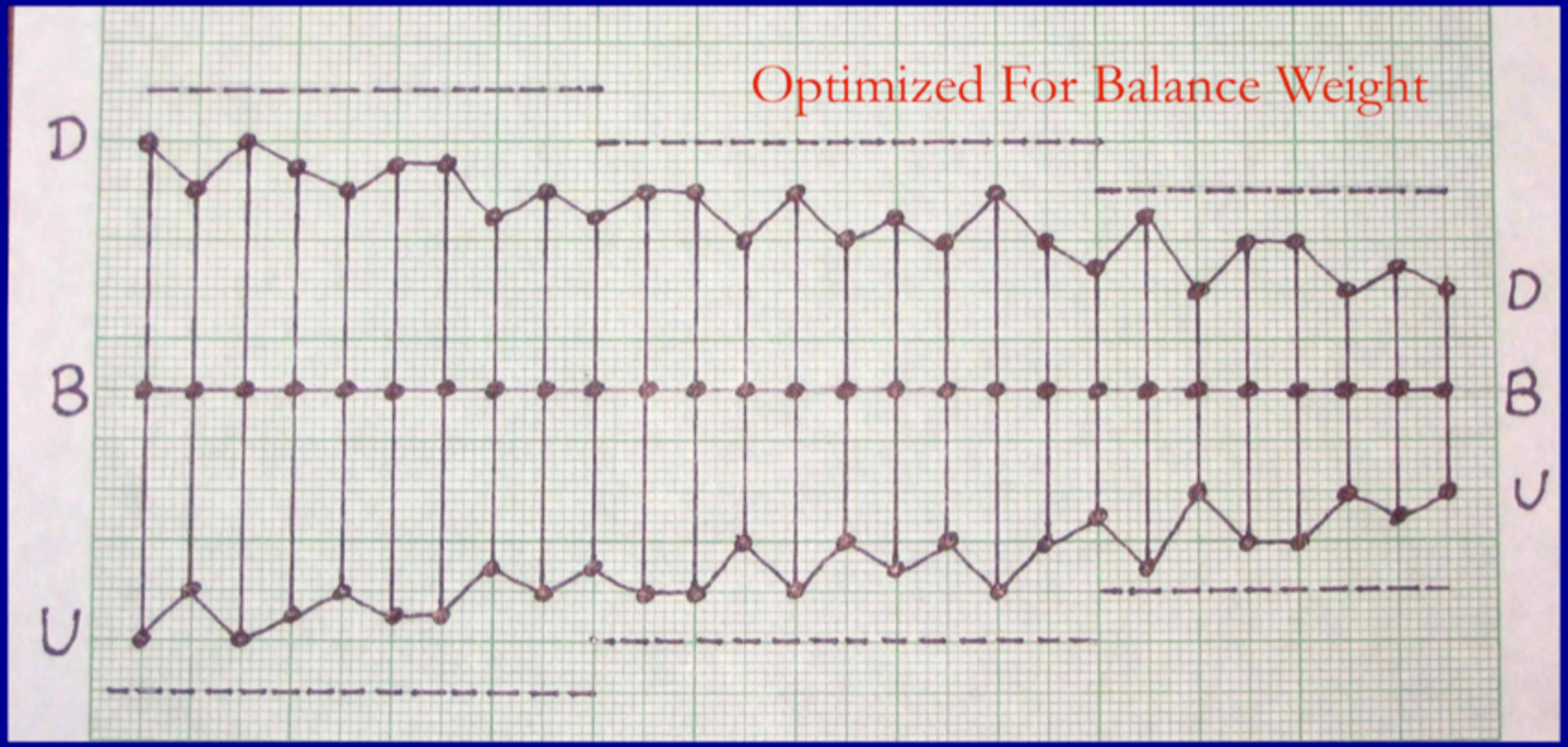
Downweight	**56**	**54**	**52**	**52**	**50**	**48**	**48**	**46**	**44**
Friction	16	15	14	13	12	11	10	9	8
Upweight	**24**	**24**	**24**	**26**	**26**	**26**	**28**	**28**	**28**
Balance Weight	40	39	38	39	38	37	38	37	37

Downweight	**53**	**52**	**51**	**50**	**49**	**48**	**47**	**46**	**45**
Friction	16	15	14	13	12	11	10	9	8
Balance Weight	**37**	**37**	**37**	**37**	**37**	**37**	**37**	**37**	**37**
Friction	16	15	14	13	12	11	10	9	8
Upweight	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**

Why Balance Weight is so essential to action weigh-off

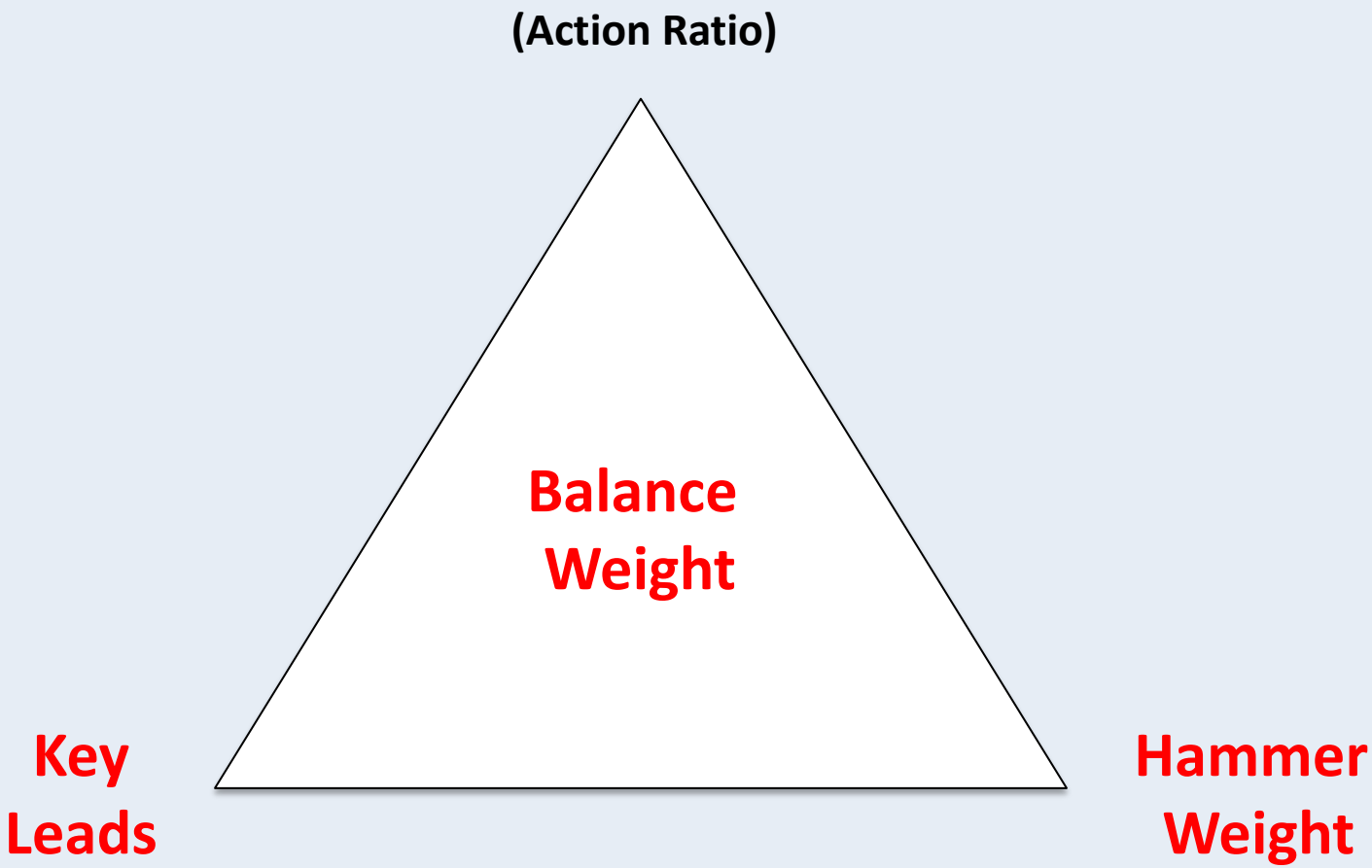


What Doesn't Affect the Balance Weight?



Friction!

What Influences Balance Weight



Subjects For 2nd Session

NOW!
The Quick, Efficient & Easy Weigh-Off Method!

The Steve Schell(RPT) Stacked/Split Weight Continual Motion Balance Weight Measuring Method

- This Weigh-Off Method **eliminates** the problems created by target Downweight or Upweight numbers.
- This Weigh-Off Method **eliminates** the need for measuring Upweight and Downweight separately.
- This Weigh-Off Method **eliminates** the need to do standard calculations for Friction and Balance Weight note-to-note.

- This Weigh-Off Method of a continuous Downweight & Upweight motion easily overcomes static friction.
- This Weigh-Off Method quickly reveals when a key assembly is not balanced.
- This Weigh-Off Method quickly reveals the Friction level of a key assembly.
- This Weigh-Off Method provides a way to easily establish Balance Weight note-to-note.

(Spurlock Style) Gram Weights

WN&G Gram Weights

What is a Suitable Balance Weight For Most Grand Actions?

37g-39g BW

(weights placed at front edge of key)

Stacks Arranged for 37g BW

Friction = Top Weight ÷ 2

BW = Upweight + Friction (½ Top Weight)

The Key Is Balanced When The "Slow" Key/Action Motion From The Total Stack Weight (DW) Is The Same As Upweight (UW)

37g BW Stacked Weight Pairs Representing A Normal Action Friction Range of 15g – 10g

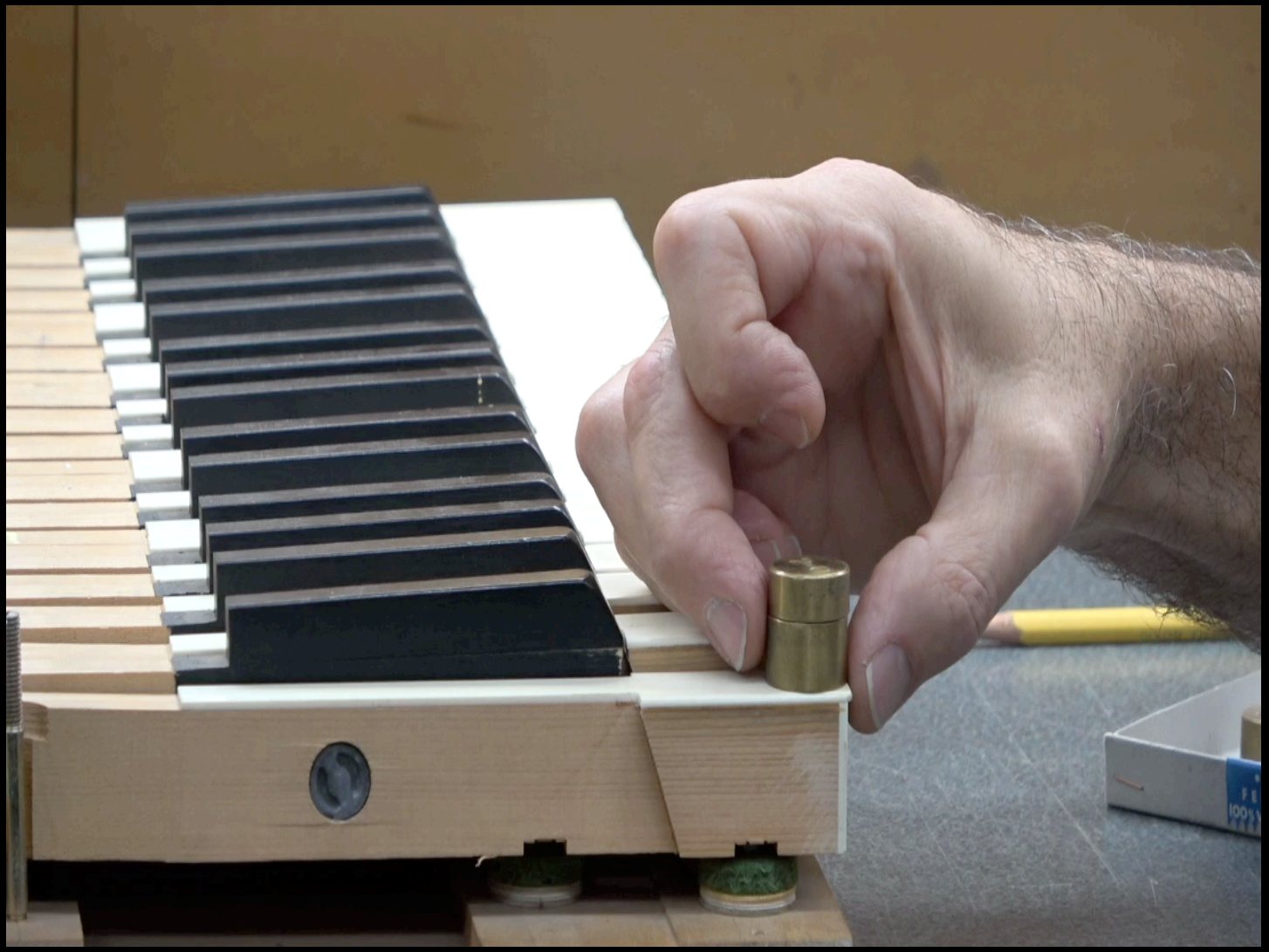
Balance Weight	37g	32	30	28	26	24	22	20	18	16g
		21	22	23	24	25	26	27	28	29g

Why 37g Balance Weight?

The Friction of a **BALANCED** key assembly will determine the weight pair needed to set the key into **a slow & even** continuous motion

(Friction does not change Balance Weight)

Balance Weight 37g	32	30	28	26	24	22	20	18	16g
	21	22	23	24	25	26	27	28	29g



Keeping the motion continuous is dependent on how the top stack is handled

Regulating Balance Weight With The Stacked/Split Weight Weigh Off Method

Stacked Weight Pairs For Desired Balance Weight

Establish BW & Choose A Weight Stack For Slowest, Even DW & UW

[Friction]	16g	15g	14g	13g	12g	11g	10g	9g	8g
Balance Weight **36g**	32g	30	28	26	24	22	20	18	**16g**
	20g	21	22	23	24	25	26	27	**28g**
Balance Weight **37g**	32g	30	28	26	24	22	20	18	16g
	21g	22	23	24	25	26	27	28	29g
Balance Weight **38g**	32g	30	28	26	24	22	20	18	16g
	22g	23	24	25	26	27	28	29	30g
Balance Weight **39g**	32g	30	28	26	24	22	20	18	16g
	23g	24	25	26	27	28	29	30	31g
Balance Weight **40g**	32g	30	28	26	24	22	20	18	16g
	24g	25	26	27	28	29	30	31	32g

36g BW = 16/28

Friction:
Top Stack ÷ 2
16 ÷ 2 = 8g

Down Weight:
Top Number Of Stack
+
Bottom Number Of Stack
16+28=44

Up Weight:
Bottom Number Of Stack
28

Balance Weight
[DW+UW÷2]
or
Top Stack ÷ 2
+ UW=BW

Friction
DW-UW÷2

– The Process –

Arrange Weight Stacks for desired Balance Weight and select weight stack in a normal friction range, i.e. 10g-12g.

Place Stack on key and observe key/action motion. If key does not move, use UW portion of the weight to see if key lifts weight. If it does, Balance Weight is too high and lead will need to be added to the key.

If Stack depresses key, but key won't lift Upweight, lead needs to be removed from the key.

– The Process –

Observe slow, continuous motion of the key by repeatedly lifting and setting the top weight. <u>This overcomes static friction.</u>

If the motion appears to be even in both directions but the speed of motion is fast, select weight stack to bracket lower friction and retest observation.

- The Process –

The chosen Balance Weight is established for a note by adding or removing lead until the observable motion of the key/action with the Stacked Weights is equal/even.

The Key Is Balanced When The "Slow" Key/Action Motion From The Total Stack Weight (DW) Is The Same As Upweight (UW)

Stacked Weight Pairs For Desired Balance Weight

Establish BW & Choose A Weight Stack For Slowest, Even DW & UW

[Friction]	16g	15g	14g	13g	12g	11g	10g	9g	8g
Balance Weight **36g**	32g	30	28	26	24	22	20	18	**16g**
	20g	21	22	23	24	25	26	27	**28g**
Balance Weight **37g**	32g	30	28	26	24	22	20	18	16g
	21g	22	23	24	25	26	27	28	29g
Balance Weight **38g**	32g	30	28	26	24	22	20	18	16g
	22g	23	24	25	26	27	28	29	30g
Balance Weight **39g**	32g	30	28	26	24	22	20	18	16g
	23g	24	25	26	27	28	29	30	31g
Balance Weight **40g**	32g	30	28	26	24	22	20	18	16g
	24g	25	26	27	28	29	30	31	32g

36g BW = 16/28

Friction:
Top Stack ÷ 2
16 ÷ 2 = 8g

Down Weight:
Top Number Of Stack
+
Bottom Number Of Stack
16+28=44

Up Weight:
Bottom Number Of Stack
28

Balance Weight
[DW+UW÷2]
or
Top Stack ÷ 2
+ UW=BW

Friction
DW-UW÷2

Regulating Balance Weight On One Octave With The Stacked/Split Weight Weigh Off Method

Weigh-Off Note To Note

- It is helpful to have some idea of the existing weigh-off status of the action, i.e. BW & F. Use "The Process For Analyzing The Balance Weight of any key assembly".
- If Balance Weight is generally very low (light action), lead must first be removed before the weigh-off process can begin.
- If Balance Weight is generally high, you must determine that the weigh-off process won't create an inertia problem from adding lead.

Weigh-Off Note To Note

- Have Stacks Arranged In Order For A Given Balance Weight.
- Have new leads ready and tools available to remove excess lead in the keys.
- Place Stack on key and observe key/action motion. If key does not move, use UW portion of the weight to see if key lifts weight. If it does, Balance Weight is too high and lead will need to be added to the key.

Weigh-Off Note To Note

- The chosen Balance Weight is established for each note by adding or removing lead until the slow, observable motion of the key/action [Dw vs. Uw] is equal/even.
- A Key assembly will not have the desired Balance Weight when the speed of motion of the key/action is different in one direction from the other.

By having these weight stacks arranged for changing friction, it is quick and easy to select the stack that will allow for the best observation of (slow) key/action movement (in conjunction with the addition or removal of lead), knowing that each stack represents the desired Balance Weight.

Stacked Weight Pairs For Desired Balance Weight

Establish BW & Choose A Weight Stack For Slowest, Even DW & UW

[Friction]	16g	15g	14g	13g	12g	11g	10g	9g	8g
Balance Weight **36g**	32g	30	28	26	24	22	20	18	**16g**
	20g	21	22	23	24	25	26	27	**28g**
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	22g	23	24	25	26	27	28	29	30g
Balance Weight **39g**	32g	30	28	26	24	22	20	18	16g
	23g	24	25	26	27	28	29	30	31g
Balance Weight **40g**	32g	30	28	26	24	22	20	18	16g
	24g	25	26	27	28	29	30	31	32g

36g BW = 16/28

Friction:
Top Stack ÷ 2
16 ÷ 2 = 8g

Down Weight:
Top Number Of Stack
+
Bottom Number Of Stack
16+28=44

Up Weight:
Bottom Number Of Stack
28

Balance Weight
[DW+UW÷2]
or
Top Stack ÷ 2
+ UW=BW

Friction
DW-UW÷2

Using the Split Weight Method to quickly analyze the existing Balance Weight and Friction of any key assembly


30 29 28 27 26 25 24 23 22 21 20 19 18 17 16

- The Process For Analyzing The Balance Weight of any key assembly –

First: Measure for Upweight – select a weight for observable slowest Hammer motion/Key lift.

Next: Add a top weight which will cause **the same** observable, slow, motion for Downweight. This Weight Will Be The Indicator Of Friction.

[Hint: First select an even # weight that is in the middle of normal friction, i.e. 22g ÷ 2 = 11g Friction]

Top Weight ÷ 2 = F Uw + F = BW

- The Process For Analyzing The Balance Weight of any key assembly –

Set the key/hammer into continual motion by repeating the action of lifting and setting top weight several times.

This action of lifting and setting the top weight easily overcomes static friction.

Adjust the top weight by 1gram _+/- until the DW/UW motion is even.

The Goal Is To Have The Even Movement As Slow As Possible

- The Process For Analyzing The Balance Weight of any key assembly –

Once You Have Determined The Slow Equal Motion Of Downweight vs. Upweight (Key/Hammer Motion) With A Given Weight Stack, divide the top stack by 2 (= Friction) and add to the bottom weight - This Equals Balance Weight!

Top Weight ÷ 2 = F Uw + F = BW

[If the speed of motion of the key/hammer is different in one direction from the other, you will not have assessed the true Balance Weight]

Stacked Weight Pairs For Desired Balance Weight

Establish BW & Choose A Weight Stack For Slowest, Even DW & UW

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	22g	23	24	25	26	27	28	29	30g
Balance Weight **39g**	32g	30	28	26	24	22	20	18	16g
	23g	24	25	26	27	28	29	30	31g
Balance Weight **40g**	32g	30	28	26	24	22	20	18	16g
	24g	25	26	27	28	29	30	31	32g

36g BW = 16/28

Friction:
Top Stack ÷ 2
16 ÷ 2 = 8g

Down Weight:
Top Number Of Stack
+
Bottom Number Of Stack
16+28=44

Up Weight:
Bottom Number Of Stack
28

Balance Weight
[DW+UW÷2]
or
Top Stack ÷ 2
+ UW=BW

Friction
DW-UW÷2

Review

- ***Balance Weight is present in every key/action assembly.***
- ***Balance Weight is something we regulate #1 - #88***
- ***Balance Weight is something we can regulate note-to-note.***

Bruce Stevens, RPT

Review

- A Change in friction affects the spread between Upweight and Downweight without changing the Balance Weight.
- A change in mass/weight at any point in the action train will change the Balance Weight.
- A change in action geometry will affect the Balance Weight.