# An Analysis on Optimizing Leveling Up Stats in Elden Ring Using Relation and Function

Anindya Naufal Pinasthika - 13524013
Program Studi Teknik Informatika
Sekolah Teknik Elektro dan Informatika
Institut Teknologi Bandung, Jalan Ganesha 10 Bandung
E-mail: naufalpinasthika@gmail.com , 13524013@std.stei.itb.ac.id

***Abstract*—Elden Ring is a RPG fantasy where one of it's core mechanic based around how a player improve their character by leveling up and choosing main stat attributes. Choosing on what main attribute to upgrade can be get really complex at first glance. This paper presents an approach on how to maximize leveling main attribute by using relation and function that will give player an effective cost runes usage doing so.**

***Keywords*— Elden Ring, Character Stats, Attribute Leveling, Relations, Functions, Optimization**

## I. Introduction

Elden Ring is an action fantasy role-playing game (RPG) that focuses on vast, expansive, and explorable open world mechanic that sets in the realm of dark fantasy setting. Elden Ring is commonly referred to as a "Soulslike" game, where it takes heavy influence on Souls franchise which feature heavy influence on difficult enemy bosses and extreme demand on high skill mechanic. In the context RPG like Elden Ring, player have a freedom of control on advancing their character in terms of attack, defense, and utility attributes.

In Elden Ring, there is a variety of character attributes based on their damage type that will contribute to the playstyle throughout the player's playthrough. Besides damage-related attributes, there are also attributes that enhance defensive or utility aspects of the character, such as increasing HP or agility. Advancing a player's character attribute in Elden Ring uses standardized leveling system where to increase their overall power level, whether in terms of purpose is to maximize damage output or to improve the character's quality of life (QOL) in the game, leveling up character requires a certain amount of resources, in Elden Ring the terms resources for leveling up character is called runes.


Fig. 1. Character Attribute Stats in Elden Ring. Source: https://www.reddit.com/r/Eldenring/comments/qmm2y7/the_official_character_stats_in_elden_ring/

Runes are the basis of the currency system in Elden Ring. These runes can be obtained by killing bosses and enemies and can be used to purchase items in shops, upgrading weapons, and, most importantly, leveling up character.

This paper aims to optimize the use of runes for leveling up character attribute to get maximum value on increase overall strength per runes spent by applying relation and function on the game's damage and runes calculation. Finding the set of relation of its respective properties will determine the optimal strategy on leveling up character in order to quickly get the most out of the runes spend.

## II. Theoretical Framework

### A. Relation

Relation is a connection that formed in a relationship between 2 sets. Given two sets, set A and set B, set A will have a relation to set B if there's a value in set A that have some

unique properties in the defined relation to set B [3]. For example, if we have set A {-1, 0, 1, 2} and set B = {0, 1, 2, 3} and we defined as the relation as follows: "The value of the set range is x + 1 of the set domain" we can map the following relation (see figure 2 below).

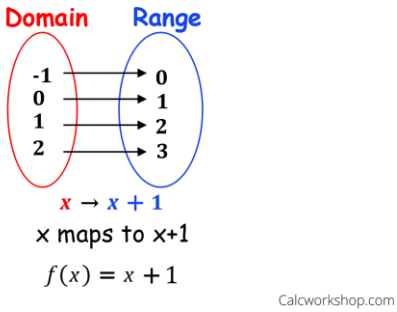


Fig. 2. Illustration of Relation. Source: https://calcworkshop.com/functions-statistics/relations-functions/

### B. *Function*

Function is a special property of relation where every element on set A is connected to set B through defined relation. In function, set A is defined as "domain" whilst set B is defined as "codomain". The term function can be expressed as follows.

$$f(a) = b \ldots (1)$$

Here, "a" represent the element in set A connected to an element "b" in set B. Element "a" must have a certain connection through relation for respective set B, if not than the relation will not be determined as function [4].

Theres 3 different types of function, with each of them hold special property:

- Injective Function (*One-to-One*)

  Injective function is a term to determine such function so that every element "a" connected one-to-one to element "b". Every domain with element "a" must have to connect to the element "b" but not every element "b" have to be mapped by its domain "a".

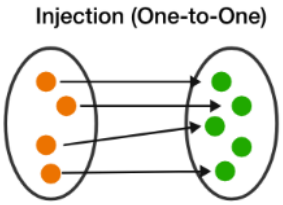


Fig. 3. Illustration Injective Functions. Source: https://brilliant.org/wiki/bijection-injection-and-surjection/

- Surjective Function (*Onto*)

  Surjective function means every element "b" must have corresponding element "a". On the same context, it is not strictly for every each one of element "a" have to connect to one "b", if given element "b" correspond to multiple element "a" then the terms still hold.

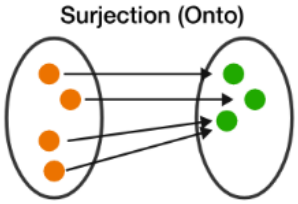


Fig. 4. Illustration Surjective Functions. Source: https://brilliant.org/wiki/bijection-injection-and-surjection/

- Bijective Function (*One-to-One and Onto*)

  Bijective function is the combination of injective and surjective function. This means so that every each one of elements "a" have to connect to each one of elements "b". If either on or both requirement doesn't meet, the terms bijective function won't hold [5].

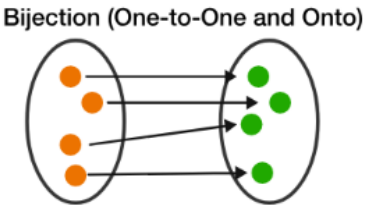


Fig. 5. Illustration Bijective Functions. Source: https://brilliant.org/wiki/bijection-injection-and-surjection/

## III. Implementation

### A. *Runes Calculation for Leveling Cost*

In Elden Ring, the runes needed on leveling up character follows a set trend function, where every domain represented as "level" can be mapped one-to-one to codomain represented as "runes cost".

| Level | Upgrade Cost | Increase | Total Spent |
|---|---|---|---|
| 1 | 673 | - | 0 |
| 2 | 689 | 16 | 673 |
| 3 | 706 | 17 | 1,362 |
| 4 | 723 | 17 | 2,068 |
| 5 | 740 | 17 | 2,791 |
| 6 | 757 | 17 | 3,531 |
| 7 | 775 | 18 | 4,288 |
| 8 | 793 | 18 | 5,063 |
| 9 | 811 | 18 | 5,856 |
| 10 | 829 | 18 | 6,667 |
| 11 | 847 | 18 | 7,496 |
| 12 | 1,038 | 191 | 8,343 |
| 13 | 1,238 | 200 | 9,381 |
| 14 | 1,445 | 207 | 10,619 |
| 15 | 1,659 | 214 | 12,064 |
| 16 | 1,882 | 223 | 13,723 |
| 17 | 2,113 | 231 | 15,605 |
| 18 | 2,353 | 240 | 17,718 |
| 19 | 2,601 | 248 | 20,071 |
| 20 | 2,857 | 256 | 22,672 |

Fig. 6. A Set of Domain "Level" to it's Codomain Represnted as "Runes Cost Represnted or Upgrade Cost". Source: https://eldenring.wiki.fextralife.com/Level

The number of runes needed to level up character can be calculated using the following formula:

$$Rune\ Cost = \left((x + 0.1) * (([Level] + 81)^2)\right) + 1 \ldots (2)$$

As for the value $x$ is a representation of another formula that follow these rules:

- If x produced by the formula (3) resulted in negative value, then set x to 0 (x must be $\geq 0$)

$$x = \left(([Level] + 81) - 92\right) * 0.02 \ldots (3)$$

The term "Level" is an input on what level we want to determine its runes cost [6].

We can implement this formula to a program.

```c
#include <stdio.h>

int main() {
    int Level;
    printf("Input level: ");
    scanf("%d", &Level);

    double x = ((Level + 81) - 92) * 0.02;
    if (x < 0) {
        x = 0;
    }

    double cost = ((x + 0.1) * (Level + 81) * (Level + 81)) + 1;
    long long runeCost = (long long)cost;

    printf("Runes needed: %lld\n", runeCost);
    return 0;
}
```

Fig. 7. Runes Cost based on Level Programmed in C. Source: Writer's Archive

From the data given, the formula (2) tend to follow quadratic function when formula (3) gives the value $x < 0$, this is because the highest power that dominate formula is $([Level] + 81)^2$ and the formula (3) gives a constant function (where if $x < 0$, set $x = 0$). As formula (3) gives the value $x$ increases if we input bigger $[Level]$ to the point where $x > 0$ (when $[Level] > 12$) , formula (3) becomes linear function. As a result, function (2) becomes cubic function as $[Level]$ becomes relevant to formula (3).

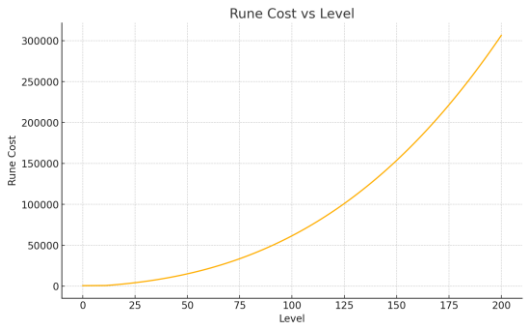


Fig. 8. Trend Graph that Contains Runes Cost Increase as the Level also Increases. Source: Writer's Archive

## B. *Attribute Stats*

Every time a player levels up, they have the freedom to choose among eight different stats. Each of the eight stats has its own level that contributes to overall character strength. This is because in Elden Ring, there are a lot of factors to consider on improving a player's character, they are not just about the leveling up character. Whether from the weapon scaling, damage types, or skills (*Ashes of War* in Elden Ring terms) required to perform the most optimal output heavily contribute on points to factor in whilst building a character in Elden Ring.

While the previous point does make up a big part of character overall improvement, leveling up and gaining one of the 8 attribute stats is always a good move to make as the character will always gradually improving overall by leveling up.

Choosing a set of attribute does have also it's certain perks and strategy. This is because the scaling in every each of attribute follows a very different set of function's trend as the attribute's level get higher and higher. Each of the main 8 attribute stats that the player can shoose whilst leveling up will have their unique property on it's function's trend. We can make a set A by using a certain threshold value as domain and we can set B as "priority". The first threshold will be considered as "soft cap" where the function onward increasing stat will start to decline. As where function stops and reach it maximum point will be considered as "hard cap".

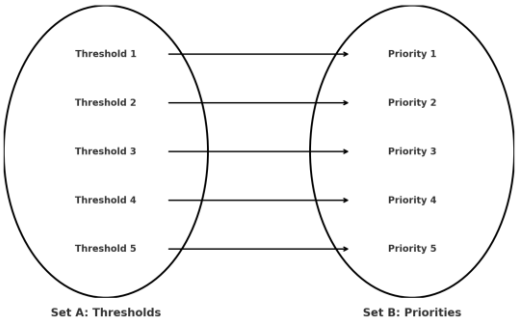


Fig. 9. Stat Threshold and it's Position on Priority Represented by Relation Graph. Source: Writer's Archive

Here are the 8 main attribute stats that player can choose when leveling up their character which each of them having a unique set of function.

- Vigor

  Vigor is a main attribute stats that make's up character *Hit Points* (HP). HP is a base stat that generally refer to as character's health and how much the character can take a damage from enemies before failing in combat [7]. Vigor is also contributed to *immunity* and *fire resistance* but the most important role for vigor is to govern the increasing HP of a character. Vigor follows a unique trendline for every vigor's attribute level

increases, the difference of health gain can be varied depend on every level.

Based on data (see VI.A), vigor gives the following stats:

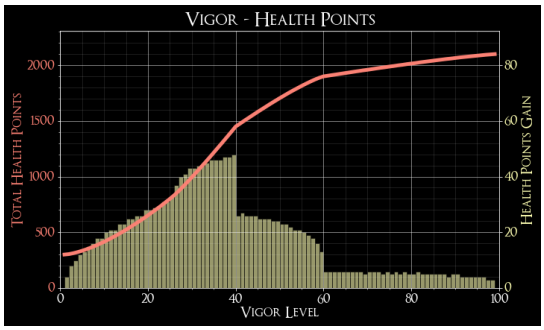


Fig. 10. Function Graph Shwowing the Difference Between HP Increase Depending on Level of Vigors Attribute. Source: https://eldenring.wiki.fextralife.com/Vigor

Based on information given, we can view that vigor attribute follows set of specific relation and function based on specific level given, most notably on level 40 and level 60 (see figure 10). In level 40 and level 60, there is a noticeable drop on HP increase that makes increasing vigor stats starts to become *diminishing returns*. We can make a 3 set of relations that contains different function that make up the difference HP increase as vigor's level's also increases.

| | |
|---|---|
| Level 1-40 | HP gain increases from +4 to +48 (avg: +29.5) |
| Level 41-60 | HP gain decreases from +26 to +13 (avg: +22.5) |
| Level 61-99 | HP gain decreases from +6 to +3 (avg: +5.1) |

Fig. 11. Difference in Average HP Increase Depending on Certain Vigors Attribute Level. Source: https://eldenring.wiki.fextralife.com/Stats

We can conclude that that a certain threshold, there is a point where it is good to stop increasing a character's level because it the amount improvement give by vigor as rune keeps increasing does not become proportional anymore. For vigor case, the level that can be achieved before it started to get diminishing returns are:

(1) Threshold 1: At level 40, where vigor reaches its first soft cap.

(2) Threshold 2: At level 60, where vigor hits its second soft cap

(3) Threshold 3: At level 99 (maximum level), where vigor reaches its hard cap.

- Mind

Mind is a main attribute stats that make's up character *Focus Points* (FP). FP usually refers to as "mana" in most RPG games that governs the use of energy needed for a character to use a special attack known as skill. When a character cast a certain skill, character will perform special set of attack that is different from the normal attack in return by using a certain amounts FP as an energy usage [9].

Based on data (see VI.B). Mind gives the following stats:

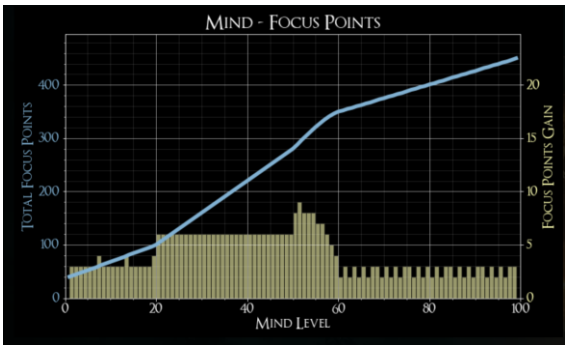


Fig. 12. Function Graph Shwowing the Difference Between FP Increase Depending on Level of Minds Attribute. Source: https://eldenring.wiki.fextralife.com/Mind

Based on data given, mind attribute gives off very different set trend by the behavior where how much FP increases as level on mind also increases. In figure 12, there's a noticable peak on level 50 to level 55, where's after level 55, the trend will go downward untill level 60. Level 60 onward will have a constant trend untill it reaches maximum level.

| | |
|---|---|
| Level 1-15 | FP gains are between +3 and +4 (LV9: +13) (avg: +3.21) |
| Level 16-35 | FP gain alternates between +5 and +6 (avg: +5.25) |
| Level 36-50 | FP gains are between +7 and +6 (avg: +6.67) |
| Level 51-60 | FP gains are between +6 and +4 (avg: +5.00) |
| Level 61-99 | FP gain alternates between +2 and +3 (avg: +2.56) |

Fig. 13. Difference in Average FP Increase Depending on Certain Minds Attribute Level. Source: https://eldenring.wiki.fextralife.com/Stats

Just like the vigor attributes, we can also conclude that mind attributes can be upgraded untill a certain treshold. Level threshold on mind attribute can be drawn by:

(1) Threshold 1: At level 55 where soft cap hits and level 55 onwards the FP increases will get diminishing returns.

(2) Threshold 2: At level 99 (maximum level), where mind reaches its hard cap.

- Endurance

Endurance is a main attribute that primarily influences stamina. The more endurance a character has, the larger the stamina bar and the more actions character can perform before requiring a recharge. Stamina is an important resource that is used up by nearly every action performed while in combat.

Another influence of endurance is on the equip load stat. A player's equip load is the sum of the weight of all their currently equipped armaments, armor, and other equipment. Raising the endurance stat also raises character's maximum equip load. The closer character's current equip load is relative to its maximum equip load, the more encumbered character become. Equip load directly influences character's ability to perform evasive rolls. This is measured against certain percentage thresholds of character's maximum equip load and will either allow character to perform long, highly evasive rolls at lower thresholds or slow and janky tumbles that have terrible evasion properties at high thresholds [10].

Based on data (see VI.C and VI.D), Endurance gives the following stats:

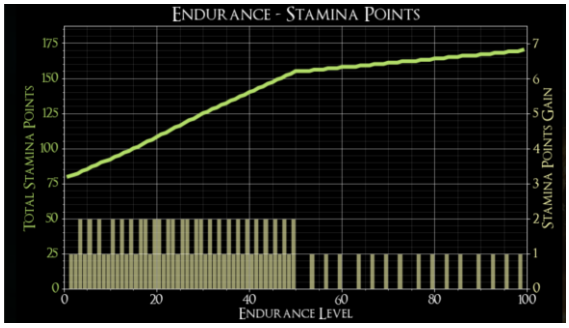


Fig. 14. Function Graph Shwowing the Difference Between Stamina Increase Depending on Level of Endurance Attribute. Source: https://eldenring.wiki.fextralife.com/Endurance

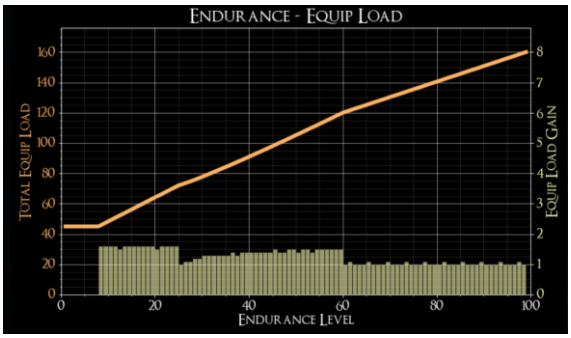


Fig. 15. Function Graph Shwowing the Difference Between Equipment Load Increase Depending on Level of Endurance Attribute. Source: https://eldenring.wiki.fextralife.com/Endurance

Endurence gives stamina and equip load attribute a very different treatment. On stamina with level 50 endurance onward, it reduce the increase to merely +1 and even +0. On the other hand, trend on equipment load increase slightly when it reaches level 25 and level 60.

| | |
|---|---|
| Level 1-15: | Stamina gains are between +1 and +2 (avg: +1.79) |
| Level 16-30: | Stamina gains are between +1 and +2 (avg: +1.67) |
| Level 31-50: | Stamina gains are between +1 and +2 (avg: +1.25) |
| Level 51-99: | Stamina gains are between +0 and +1 (avg: +0.31) |

Fig. 16. Difference in Average Stamina Increase Depending on Certain Endurances Attribute Level. Source: https://eldenring.wiki.fextralife.com/Stats

| | |
|---|---|
| Level 9-25: | Max Equip Load gains alternate between +1.5 and +1.6 (avg: +1.59) |
| Level 26-60: | Max Equip Load gains are between +1.0 and +1.5 (avg: +1.37) |
| Level 61-99: | Max Equip Load gains are between +1.0 and +1.1 (avg: +1.03) |

Fig. 17. Difference in Average Equipment Load Increase Depending on Certain Endurances Attribute Level. Source: https://eldenring.wiki.fextralife.com/Stats

From endurance case, there is a multiple case to consider by having 2 sub-attribute with each of them with each of them have different set of threshold:

(1) Stamina Threshold 1: At level 50, it reaches it soft cap and onward the returns on stamina will significantly decreasing.

(2) Stamina Threshold 2: At level 99 (maximum level), where stamina reaches its hard cap.

(3) Equipment Threshold 1: At level 0 to level 25, the increase on equipment reaches its first soft cap.

(4) Equipment Threshold 2: At level 25 to level 60, the growth started to noticeably decrease and reaches its second soft cap.

(5) Equipment Threshold 3: Level 60 onward will start to decrease again until level 99 where it reaches hard cap.

- Strength and Dexterity

Strength (STR) and dexterity (DEX) are main attribute that acts as the primary modifier that influences the damage dealt by such weapons via scaling and gives the character the ability to wield such armaments (weapons). The difference between strength and dexterity is strength generally used for heavy armaments and gives minor stats such as physical defense [11], while dexterity focus primarily on more lighter weapons and reduces casting time of spells, softens fall damage, and makes it harder to be knocked off character's horse [12].

Weapons are given a scaling grade denoting the degree to which they scale with an attribute. Each point allocated to the strength/dexterity stat increases the damage dealt by weapons with strength/dexterity scaling. For example, weapon with a strength scaling grade of S will benefit the most from the strength attribute, followed by grades A, B, C, D, and E.

When scaling the attack power of a melee armament, like all stats, strength and dexterity have similarities as both directly influence weapon damage using scaling damage. This is because on the case of strength and dexterity, what directly influence the damage dealt by its character and its soft caps differ depending on the melee weapon and the damage type being scaled. Scaling on melee weapon with physical damage is often 18/60/80 by default, 20/60/80 on heavy affinities and some unique weapons, and 16/60/80 on quality affinities. Strength has a hard cap of 150 when scaling physical damage. Note that in the rare case that magic, fire, lightning, or holy scales on strength, the soft caps are always 20/50/80.

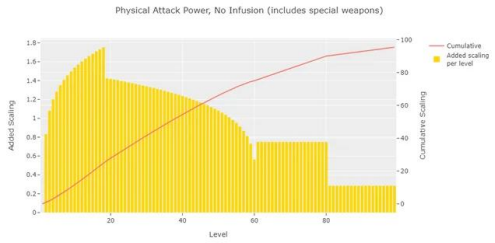


Fig. 18. Function Graph Shwowing the Difference Between Physical Attack Increase Using no Affinity Depending on Level of Strength/Dexterity Attribute. Source: https://www.reddit.com/r/Eldenring/comments/tc3lyy/helpful_charts_for_offensive_stat_scaling/

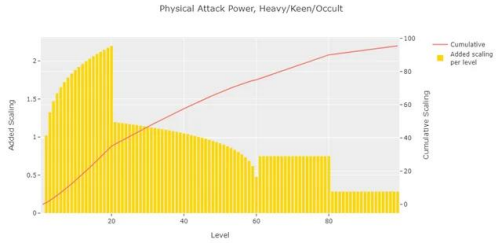


Fig. 19. Function Graph Shwowing the Difference Between Physical Attack Increase Using Heavy/Keen/Occult Affinity Depending on Level of Strength/Dexterity Attribute. Source: https://www.reddit.com/r/Eldenring/comments/tc3lyy/helpful_charts_for_offensive_stat_scaling/

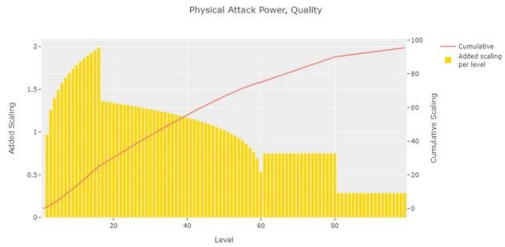


Fig. 20. Function Graph Shwowing the Difference Between Physical Attack Increase Using Quality Affinity Depending on Level of Strength/Dexterity Attribute. Source: https://www.reddit.com/r/Eldenring/comments/tc3lyy/helpful_charts_for_offensive_stat_scaling/

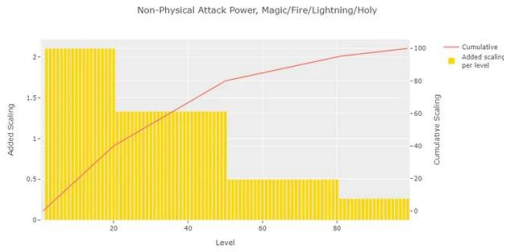


Fig. 21. Function Graph Shwowing the Difference Between Physical Attack Increase on Hybrid Damage Weapon Depending on Level of Strength/Dexterity Attribute. Source: https://www.reddit.com/r/Eldenring/comments/tc3lyy/helpful_charts_for_offensive_stat_scaling/

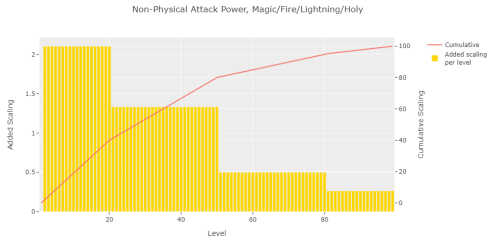


Fig. 22. Function Graph Shwowing the Difference Between Non- Physical Attack Increase Hybrid Damage Weapon Depending on Level of Strength/Dexterity Attribute.. Source: https://www.reddit.com/r/Eldenring/comments/tc3lyy/helpful_charts_for_offensive_stat_scaling/

From data given, it's clear although there is a lot of variable and case to be given, but there is a clear trend line on different type of affinities given by the weapon that it shows similar threshold, by this information, we can conclude that at a certain threshold:

(1) Threshold 1: If weapon type and affinities generally use physical attack and not using split damage to magic/fire/lighting/holy, then at level 60 it reaches it ideal soft cap. If it is the latter, the ideal soft cap is at level 50.

(2) Threshold 2: At level 99 where it reaches the hard cap.

- Intelligence and Faith

Intelligence (INT) and faith (FAI) are main attribute that is required to cast most sorceries. It is also a primary requirement for equipping the weapons required to cast these spells. The difference between intelligent and faith is intelligent focuses on casting magic sorceries with projectile and spells and increases magic resistance [13], while faith focuses incantation with generally have a wide variety of spells including offensive, defensive utility, and self-buffs [14].

INT and FAI weapons are also given a Scaling Grade denoting the degree to which they scale with an attribute. Scaling grade of S will benefit the most from the INT and FAI attribute, followed by grades A, B, C, D, and E

When scaling the attack power of a melee armament, like all stats, intelligence and faith soft caps differ depending on the weapon and the damage type being scaled. Scaling on magic, fire, lightning, or holy damage is always 20/50/80. Scaling on physical damage may be 18/60/80 (see figure 21).

Although there is a lot a special case with certain staff, spells, and incantation. The general threshold that can be used as set of relation

(1) Threshold 1: If weapon type and affinities generally use split hybrid physical attack and magic/fire/lighting/holy, then at level 50 it reaches it ideal soft cap. If using pure magic/fire/lighting/holy, the ideal soft cap is level 60

(2) Threshold 2: At level 99 where it reaches the hard cap.

- Arcane

Arcane is primary way of increasing character's discovery stat. The higher character's discovery the higher the chance items will drop from enemies, including making rare drops less rare. Every character has a base of 100 discovery flat rate of +1 discovery per arcane level. Arcane also primarily increases character's holy defense, which increases your defense against attacks that deal holy damage and character's vitality, which increases character's resistance to death blight [15] (status effect where if the meter filled, character will die instantly [16]).

Like every offensive attribute stat mentioned earlier, weapons with attribute that can proceeding poison, bleed, madness, and sleep scale with arcane and on weapons that have arcane scaling on them require a certain number of levels in arcane to be able to wield them effectively.

When scaling the attack power of a melee armament, like all stats, arcane soft caps differ depending on the weapon and the damage type being scaled.


Fig. 23. Difference Between FP Increase Depending on Level of Mind. Source: https://www.reddit.com/r/Eldenring/comments/tc3lyy/helpful_charts_for_offensive_stat_scaling/

Arcane is main stat that have a clear point where stat increases become less as level's keep increasing. In arcane, there is a clear indication that:

(1) Threshold 1: at level 25 reaches its first soft cap

(2) Threshold 2: at level 45 reaches its second soft cap

(3) Threshold 3: At level 99 where it reaches the hard cap.

## IV. Optimization Result

After we gather all the information on relation and function of threshold needed for a general optimal "stop" at leveling attribute stat, we can optimize runes usage for leveling up stats as follows:

- Vigor: Level 40 (if pushing for second soft cap then level 60 otherwise)
- Mind: Level 55
- Endurance: Level 25 (level 50 if focuses on stamina or level 60 if focuses on equipment load)
- Strength and Dexterity: Level 60 (level 50 if using hybrid damage)
- Intelligent and Faith: Level 60 (level 50 if using hybrid damage)
- Arcane: Level 45 (if pushing for second soft cap then level 60 otherwise)

## V. Conclusion

Determining a certain threshold of a character improvement on leveling up system with complex set of different playstyles and build in RPG game like Elden Ring can be very difficult.

In this paper, we explore on how we can use relation and function approach by observing its dataset and graphical function on every stat increase to determine its set relation using threshold on a certain value. Determining the set of relation and function can lead to finding optimization that can make spending runes in Elden Ring more effective on leveling up character.

## VI. Appendix

The dataset used for this paper are as follows:

A. vigor_dataset.csv [8]
B. mind_dataset.csv [9]
C. stamina_dataset [10]
D. equip_load_dataset [10]
E. GitHub Repositories: https://github.com/Naufal-Pinasthika/Makalah-Matdis

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PERNYATAAN

Dengan ini saya menyatakan bahwa makalah yang saya tulis ini adalah tulisan saya sendiri, bukan saduran, atau terjemahan dari makalah orang lain, dan bukan plagiasi.

Bandung, 1 Juni 2025

Anindya Naufal Pinasthika (13524013)