1. How do Individual Values (IV) work?

- Three statistics define a Pokémon: the attack statistic defines the damages your Pokémon will do, the defence statistic defines the speed at which your Pokémon will die, the HP is your Pokémon's Health Points.
- We consider the example of Mewtwo. Mewtwo's base statistics are:

	Mewtwo
Base_ATT	300
Base_DEF	182
Base_HP	214

(source: `https://pokemon.gameinfo.io/fr/pokemon/150-mewtwo`).

Assume you are very lucky, and you caught a perfect Mewtwo, with (ATK_IV, DEF_IV, HP_IV) = (15, 15, 15). Your perfect Mewtwo's stats are:

Base_ATT + ATK_IV	315
Base_DEF + DEF_IV	197
Base_HP + HP_IV	229

- Depending on the level of your Pokémon, you will multiply all these stats by a coefficients given in the following table:

Level 20	Level 25	Level 30	Level 35	Level 40
0.5974	0.667934	0.7317	0.76156384	0.7903

This table tells that: at level 25, your Pokemon is at 84.5% of its capacity; at level 30, your Pokemon is at 92.6% of its capacity; at level 35, your Pokemon is at 96.4% of its capacity.

Coming back to Mewtwo, if you level up it to level 30, its statistics are finally:

ATT = (ATT + ATK_IV) at level 30	230
DEF = (DEF + DEF_IV) at level 30	144
HP = (HP + HP_IV) at level 30	167

- CP formula is:

$$\text{CP} = \text{floor}\left(\frac{\text{ATT}\times\sqrt{\text{DEF}\times\text{HP}}}{10}\right) = \text{floor}\left(\frac{230\times\sqrt{144\times167}}{10}\right) = 3566$$

2. How to measure the bulkiness of a Pokémon?

- We use the **effective health** (EH) defined by : EH $\propto$ DEF $\times$ HP. The higher the score is, the bulkier the Pokémon is. For instance:

	Tangrowth GRASS	**Exeggutor (A)** GRASS DRAGON
		
Base_ATT	207	230
Base_DEF	184	153
Base_HP	225	216

Tangrowth's base Effective Health is $184 \times 225 = 41400$, whereas Exeggutor (A)'s base Effective Health is $153 \times 216 = 33048$.

- However, it is also interesting to consider resistances when it comes to compare Pokémon.

Double vulnerability	$\times 0.39$
Vulnerability	$\times 0.63$
Normal	$\times 1$
Simple Resistance	$\times 1.6$
Double Resistance	$\times 2.56$

If we use these two Pokémon versus Kyogre (Waterfall + Hydro Pump), Tangrowth's base Effective Health is $41400 \times 1.6 = 66240$, whereas Exeggutor (A)'s base Effective Health is $33048 \times 2.56 = 84602.88$. Therefore, Exeggutor (A) will be more resistant versus Kyogre (Hydro Pump) than Tangrowth.

3. How to compute the damage realised by a Pokémon?

The damage a Pokémon will do to its opponent is given by:

$$\text{Damage formula} = \text{floor}\left(\frac{1}{2}\text{Power} \times \frac{\text{ATT}}{\text{OPP\_DEF}} \times \text{Multiplier}\right) + 1$$

To illustrate this formula we consider an Exeggutor (A) perfect at level 30 launching Solar Beam to a Kyogre at level 40.

- floor $() + 1$ guarantees that the minimum damage of any attack is 1.
- Power is the power of the considered move, for Solar Beam, it is 180.
- ATT is the giver's attack statistic. For instance, for Exeggutor (A) at level 30 with 15 as IV_ATT, it would be $(230+15)\times 0.7317 = 179$.
- OPP_DEF is the opponent's defense statistic. For instance, for Kyogre at level 40 with 15 as IV_DEF, it would be $(228+15)\times 0.7903 = 192$.
- Multipliers could be STAB, WAB, FAB and Effectiveness.
- STAB is an acronym for Same Type Attack Bonus. If a Pokemon uses a move that matches one of its types, then the attack damage gets a $\times 1.2$ multiplier.
- WAB is an acronym for Weather Attack Bonus. If a Pokemon uses a move that matches one of the boosted types in the current weather, then the attack gets a $\times 1.2$ multiplier, same as that of STAB.
- FAB is an acronym for Friendship Attack Bonus. Friend bonuses are 3%, 5%, 7% or 10% depending on your level of friendship.
- Effectiveness refers to the multiplier applied to using a "super effective" or "not very effective" move.

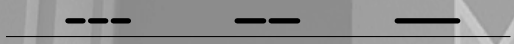
Not very effective (at all!)	$\times 0.39$
Not very effective	$\times 0.63$
Normal	$\times 1$
Super effective	$\times 1.6$
(Super!) super effective	$\times 2.56$

Under no weather boost, no friendship bonus, the damages Exeggutor will do to Kyogre are:

$$\text{Damage formula} =$$
$$\text{floor}\left(\frac{1}{2}\text{Power} \times \frac{\text{ATT}}{\text{OPP\_DEF}} \times \text{Multiplier}\right) + 1 = \text{floor}\left(\frac{1}{2}180 \times \frac{179}{192} \times 1.2 \times 1.6\right) + 1 = 161 + 1 = 162 \text{ HP}$$

4. Which moves to choose for a Pokemon?

- Each Pokemon has a fast move and a charged move. Both together define the damages the Pokémon will realise.
- Each move is defined by the damage it realises, its duration and the energy it generates (for fast moves) or uses (for charged moves).
- Charged move energies are defined by the number of bars:



energy of 33.33	energy of 50	energy of 100

- The goal is then to choose the best moves that realise the **most damages per second**. We consider the example of Metagross: is Meteor Mash or Flash Cannon more interesting? From `https://pokemon.gameinfo.io`, we get the following table:

	Meteor Mash	Flash Cannon
Base damage	100	100
Move duration	2600 ms	2700 ms
Damage window	2300 - 2500 ms	1600 - 2500 ms
Energy	-50	-100
DPS	38.5	37
EPS	-19.2	-37

DPS is the damage per second for this move (= Base damage/Move duration), whereas EPS is the energy used per second (= Base damage/Energy).
Both attacks realise 100 as base damage, and have similar Move duration. However Meteor Mash needs less energy than Flash Cannon; a player will launch two Meteor Mash for one Flash Cannon, and realise twice more damage in the same time. This is reflected in the EPS.
Therefore, Meteor Mash is much more interesting than Flash Cannon.

- We usually compute the global and neutral DPS for each couple (fast, charge) to see the number of damage per second the Pokémon realises by combining its fast and charged moves.
Computation is complex, as it needs to consider also the damage realised by the opponent which brings energy to the giver. The DPS must also consider "Same Type Attack Bonus" (STAB, 25% damage boost of a move when it is the same type as one of the types of the Pokémon using the move).

▸ How DPS is computed? ▸ Comprehensive DPS/TDO spreadsheet

For Metagross, DPS of (Bullet Punch, Meteor Mash) is much higher than DPS of (Bullet Punch, Flash Cannon):

Pokemon	Fast Move	Charged Move	DPS	TDO	$DPS^3 \times$ TDO	CP
Metagross	Bullet Punch	Meteor Mash	17.983	621.7	3615.5	3791
Metagross	Bullet Punch	Flash Cannon	13.563	468.9 1	169.7	3791

5. Which Pokemon to choose for levelling up?

They must be chosen based on their:

- Damage Per Second (DPS) defined by their fast and charged move: it represents how much damage a Pokémon can make in a second.
- Effective Health (EH) is computed via the formula (at level 40):

$$\text{EH} = (\text{base DEF} + \text{DEF\_IV}) \times (\text{base HP} + \text{HP\_IV}) \times \frac{0.7903^2}{900}$$

- Total Damage Output (TDO) represents how much damage a Pokémon can make before it faints. It is computed via TDO = DPS × EH
- $\text{DPS}^3 \times$ TDO, a mathematical measure without any physical sense, that can help to order Pokémon.

▸ Comprehensive DPS/TDO spreadsheet

For instance, if we compare the two best Ghost-type Pokémon:

Pokemon	Fast Move	Charged Move	DPS	TDO	$\text{DPS}^3 \times$ TDO	CP
Gengar	Lick	Shadow Ball	18.109	350.4	2080.9	2878
Giratina (Origin)	Shadow Claw	Shadow Ball	15.814	662.8	2621.4	3683

Gengar has a monstrous DPS, but low TDO, whereas Giratina (O) has excellent EH and TDO. The global measure $\text{DPS}^3 \times$ TDO recommends Giratina (O).
Note also that weaknesses are not taken in this spreadsheet, as we compute the neutral DPS. If we choose "Mewtwo" with (Confusion, Psychic) as opponent, the spreadsheet becomes:

Pokemon	Fast Move	Charged Move	DPS	TDO	$\text{DPS}^3 \times$ TDO	CP
Gengar	Lick	Shadow Ball	27.547	194.4	4063.3	2878
Giratina (Origin)	Shadow Claw	Shadow Ball	26.415	641.9	11829.9	3683

DPS has increased by ≈ 1.6 (as Mewtwo is weak to Ghost attacks), but Gengar's TDO has also decreased (due to Mewtwo's statistics and moves, and Gengar's psychic weakness) at the same time, making it not viable.

6. How difficult are Raid bosses?

Raid boss have the attack and defend statistics of a perfect level 40 Pokémon, but their HP depends on the difficulty of the raid:

Difficulty	HP	Time
1	600 HP	180s
2	1,800 HP	180s
3	3,600 HP	180s
4	9,000 HP	180s
5 (Legendary)	15,000 HP	300s
6 (Mewtwo)	22,500 HP	300s

For example, Kyogre's base statistics are: As a raid boss, they will be:

	Kyogre		**Kyogre**
Base_ATT	270	ATT	225
Base_DEF	228	DEF	192
Base_HP	205	HP	15,000 HP

- Damages realised by the raid boss are identical to a Pokémon level 40 with ATK_IV = 15.
- For a 5-head boss, you must realise $15000/300 = 50$ HP per second; same damage to realise per second for a 4-head boss. The main difficulty of a 5-head boss is that it has more HP, and therefore you will need more time, more Pokémon and more revives.
- Difficulty of a raid boss will mainly depends on **the boss defence statistic** (the higher is defense is, the more time you will need to defeat it).
- **You need to play on resistance of your Pokémon, if you want to use less potion to defeat it**
- **You need to play on the boss vulnerability, if you want to defeat it faster.**

7. How are IV important? What is the optimal level for a Pokémon?

Regarding IVs, they depend on the Pokémon base statistics.

- If the Pokémon has an important base attack statistic, there will be no difference between ATK_IV $= 14$ and ATK_IV $= 15$.
  It is recommended to that a high ATK_IV for Pokémon with low DPS.
- Regarding to bulkiness (DEF_IV and HP_IV), the defence statistic influences how fast your Pokémon will die, whereas the HP statistic tells you the total number of HP your Pokémon will have. Usually, it is more interesting to have a higher DEF_IV than HP_IV.
  It is recommended to that a high DEF_IV and HP_IV for Pokémon with low Effective Health.

The more you want to level up your Pokémon, the more expansive it will be. Level 35 is fine (where your Pokémon is at 96.4% of its capacity), but level 30 is good too (92.6% of its capacity).

$$\text{Level } 20 \xrightarrow[31{,}000]{28} \text{Level } 25 \xrightarrow[44{,}000]{38} \text{Level } 30 \xrightarrow[62{,}000]{64} \text{Level } 35 \xrightarrow[88{,}000]{118} \text{Level } 40$$

There is an ideal level depending on each Pokémon and its opponent:

- above a certain level, it will not be more resistant (its oponent will be able to inflige a certain number of fast and charged attacks until your Pokémon dies). It is called the *bulkpoint*.
- above a certain level (usually different from the bulkpoint), your Pokémon fast attack will do exactly the same damage (it's due to the floor in the damage formula). It is called the *breakpoint*.

For levelling up a Pokémon after level 35, if base stat ≈ 125, the difference between an IV 15 and an IV 14 is **one level**. If base stat ≈ 265, the difference between an IV 15 and an IV 14 is **one half-level**.