

# Gotta solve 'em all!

Choosing the perfect Pokémon team with mathematical programming

@GeraintPalmer



# Pokémon?



<https://gamefaqs.gamespot.com/>

# Blastoise



Water

HP: 79  
Attack: 83  
Special Attack: 85  
Defence: 100  
Special Defence: 105  
Speed: 78

Hydro Pump Pwr: 110  
Acc:80%

Bite Pwr: 60  
Acc:100%

Ice Beam Pwr: 90  
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Surf Pwr: 90  
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- Currently 809 different Pokémon.
- Play with a team of 6.
- ${}^{806}C_6 \approx 3.82 \times 10^{14}$  choices.

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stars in the Milky Way  $(4 \times 10^{11})$   $<$  Pokémon teams  $(3.82 \times 10^{14})$   $<$  grains of sand on Earth  $(7 \times 10^{18})$

<p>Normal</p> 	<p>Fire</p> 	<p>Water</p> 	<p>Electric</p> 	<p>Grass</p> 	<p>Ice</p> 
<p>Fighting</p> 	<p>Poison</p> 	<p>Ground</p> 	<p>Flying</p> 	<p>Psychic</p> 	<p>Bug</p> 
<p>Rock</p> 	<p>Ghost</p> 	<p>Dragon</p> 	<p>Dark</p> 	<p>Steel</p> 	<p>Fairy</p> 

		Move																		
		Normal	Fire	Water	Electric	Grass	Ice	Fighting	Poison	Ground	Flying	Psychic	Bug	Rock	Ghost	Dragon	Dark	Steel	Fairy	
Pokémon	Normal	1	1	1	1	1	1	2	1	1	1	1	1	1	0	1	1	1	1	
	Fire	1	½	2	1	½	½	1	1	2	1	1	½	2	1	1	1	½	½	
	Water	1	½	½	2	2	½	1	1	1	1	1	1	1	1	1	1	½	1	
	Electric	1	1	1	½	1	1	1	1	2	½	1	1	1	1	1	1	½	1	
	Grass	1	2	½	½	½	2	1	2	½	2	1	2	1	1	1	1	1	1	
	Ice	1	2	1	1	1	½	2	1	1	1	1	1	2	1	1	1	2	1	
	Fighting	1	1	1	1	1	1	1	1	1	2	2	½	½	1	1	½	1	2	
	Poison	1	1	1	1	½	1	½	½	2	1	2	½	1	1	1	1	1	½	
	Ground	1	1	2	0	2	2	1	½	1	1	1	1	½	1	1	1	1	1	
	Flying	1	1	1	2	½	2	½	1	0	1	1	½	2	1	1	1	1	1	
	Psychic	1	1	1	1	1	1	½	1	1	1	½	2	1	2	1	2	1	1	
	Bug	1	2	1	1	½	1	½	1	½	2	1	1	2	1	1	1	1	1	
	Rock	½	½	2	1	2	1	2	½	2	½	1	1	1	1	1	1	2	1	
	Ghost	0	1	1	1	1	1	0	½	1	1	1	½	1	2	1	2	1	1	
	Dragon	1	½	½	½	½	2	1	1	1	1	1	1	1	1	2	1	1	2	
	Dark	1	1	1	1	1	1	2	1	1	1	0	2	1	½	1	½	1	2	
	Steel	½	2	1	1	½	½	2	0	2	½	½	½	½	1	½	1	½	½	
	Fairy	1	1	1	1	1	1	½	2	1	1	1	½	1	1	0	½	2	1	

# The Objective

- Choose a team of 6 Pokémon
  - So that their stats are maximised
  - So that there is an option to be resistant to every type
  - So there is no more than one starter Pokémon
  - So there are no mythical, legendary or pseudolegendarly Pokémon
- 
- Choose 4 moves for each team member
  - So that expected damage is maximised
  - So that there's at least one move of each type

## Sidebar...

I make £50 profit on paint A, and £60 profit on paint B.

Paint A needs 4 tonnes of X and 5 tonnes of Y.

Paint B needs 6 tonnes of X and 4 tonnes of Y.

Only 24 tonnes of X and 20 tonnes of Y available per day.

How much of paint A and paint B should I produce daily to maximise profit?

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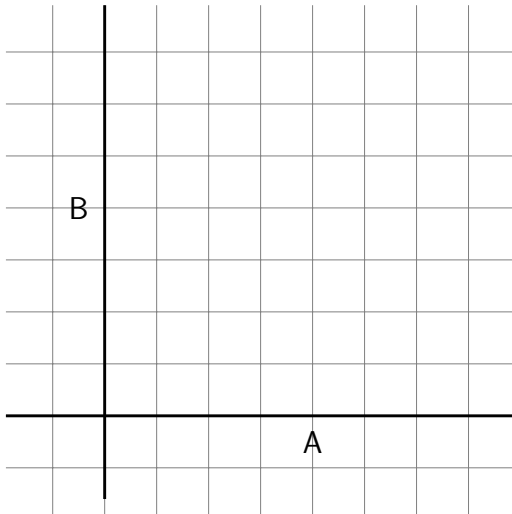
Maximise:  $50 \mathbf{A} + 60 \mathbf{B}$

Constraints:

Material X:  $4 \mathbf{A} + 6 \mathbf{B} \leq 24$

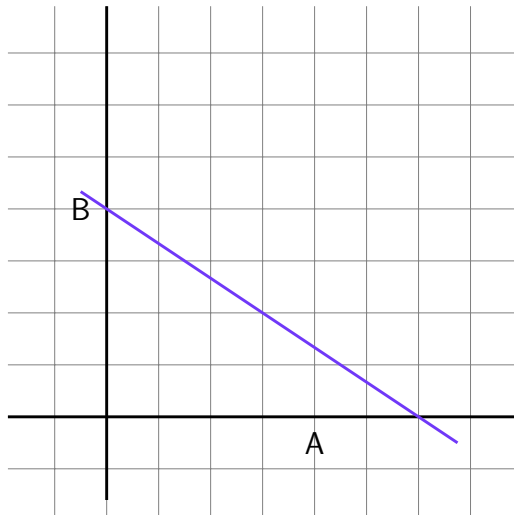
Material Y:  $5 \mathbf{A} + 4 \mathbf{B} \leq 20$

## Sidebar...



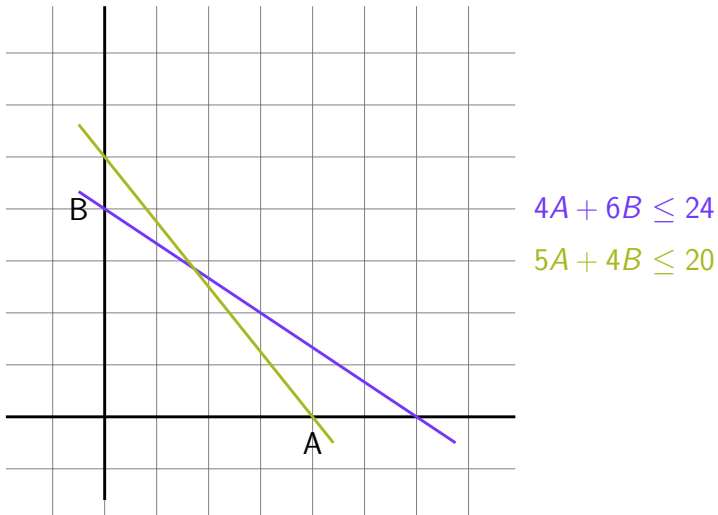


## Sidebar...

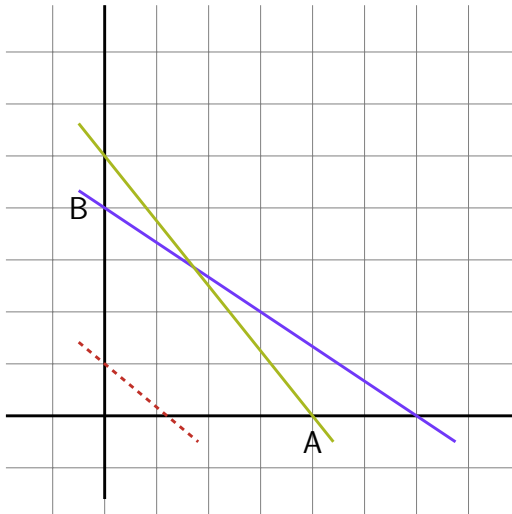


$$4A + 6B \leq 24$$

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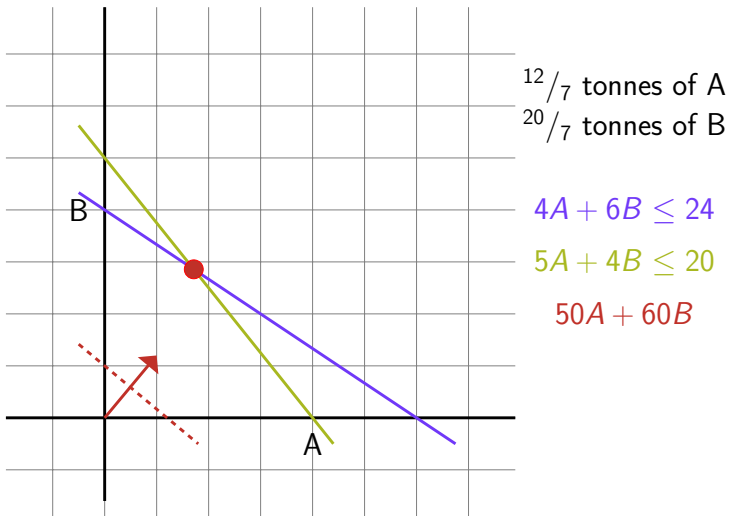


$$4A + 6B \leq 24$$

$$5A + 4B \leq 20$$

$$50A + 60B$$

## Sidebar...



# The First Model

- $\mathcal{T}$  set of types
- $X_i$  decision to choose Pokémon  $i$
- $Z_i$  a statistic of Pokémon  $i$
- $R_{it}$  if Pokémon  $i$  resistant to type  $t$
- $S$  set of starter Pokémon
- $L$  set of mythical, legendary and pseudolegendarary Pokémon

## The First Model

$$\text{maximise } \sum_i Z_i X_i$$

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$$\text{maximise } \sum_i Z_i X_i$$

$$\sum_i X_i = 6$$

$$\sum_{i \in S} X_i \leq 1$$

$$\sum_{i \in L} X_i = 0$$

$$\sum_i R_{it} X_i \geq 1 \quad \forall t \in \mathcal{T}$$



$Z = \text{Total stats}$



$Z = \text{Attack} + \text{Special Attack}$



$Z = \text{Defence} + \text{Special Defence} + \text{HP}$



$Z = \text{Speed}$

## The Second Model

- $\mathcal{X}$  the set of chosen Pokémon
- $\mathcal{M}$  the set of damaging moves
- $Y_{ij}$  decision to choose move  $j$  for Pokémon  $i$
- $\theta_{ij}$  if Pokémon  $i$  has same type as move  $j$
- $\mathbb{E}[D_j]$  the expected damage of move  $j$
- $M_{ij}$  can Pokémon  $i$  learn move  $j$
- $T_{jt}$  if move  $j$  of type  $t$

## The Second Model

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$$\sum_j Y_{ij} = 4 \quad \forall i \in \mathcal{X}$$

$$Y_{ij} \leq M_{ij} \quad \forall j \in \mathcal{M}, i \in \mathcal{X}$$

$$\sum_j Y_{ij} T_{jt} \geq 1 \quad \forall t \in \mathcal{T}, i \in \mathcal{X}$$

## Arcanine



Overheat

Crunch

Burn Up

Flare Blitz

## Archeops



Sky Attack

Shadow Claw

Head Smash

Earthquake

## Florges



Psychic

Petal Dance

Moonblast

Hyper Beam

## Haxorus



Surf

Poison Jab

Outrage

Draco Meteor

## Magnezone



Wild Charge

Thunderbolt

Signal Beam

Iron Head

## Slaking



Ice Beam

Hyper Beam

Giga Impact

Focus Punch



# Flaws / Potential Improvements / Further Work

- Pokémon choice does not consider move choice.
- Move choice does not consider opponent type.
- Pokémon choice does not consider 'spread' of statistics.

# Acknowledgements

- Special thanks to [Joe Bishop](#) for obtaining the all data!
- All images courtesy of [Bulbapedia](#) under version 2.5 of the Creative Commons Attribution-NonCommercial-ShareAlike license.
- Linear programs solves using [PuLP](#) with Python.