Decentralized Finance

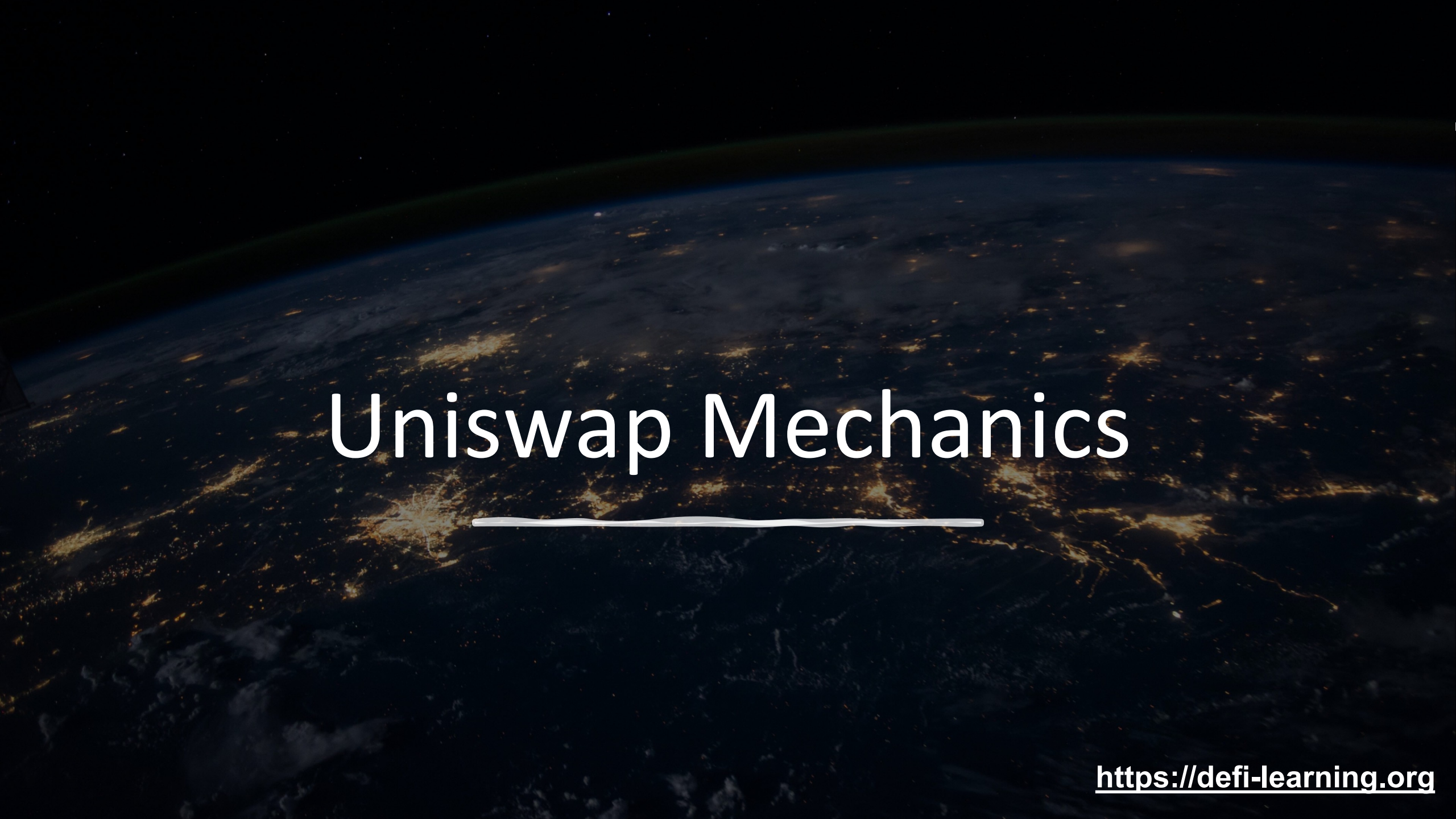
Case Study: Uniswap

Guest Lecture: **Dan Robinson** (Paradigm)

Paradigm

Uniswap

- Decentralized exchange on Ethereum
  - >$10 billion volume per week, >$6 billion of tokens used as liquidity
- Permissionless
  - Anyone can create a trading pair for any two ERC-20 tokens
- Non-custodial
  - Nobody can shut it down or steal funds (unless the blockchain is compromised or the smart contracts have a bug)
- Censorship-resistant
  - Anyone who can send transactions on Ethereum can use it



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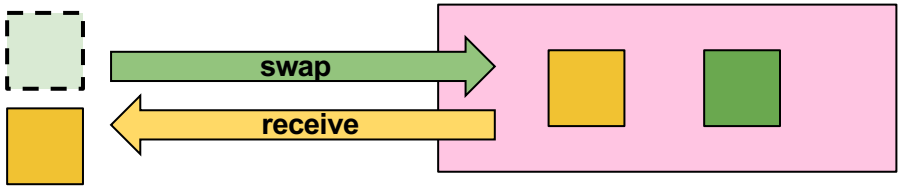
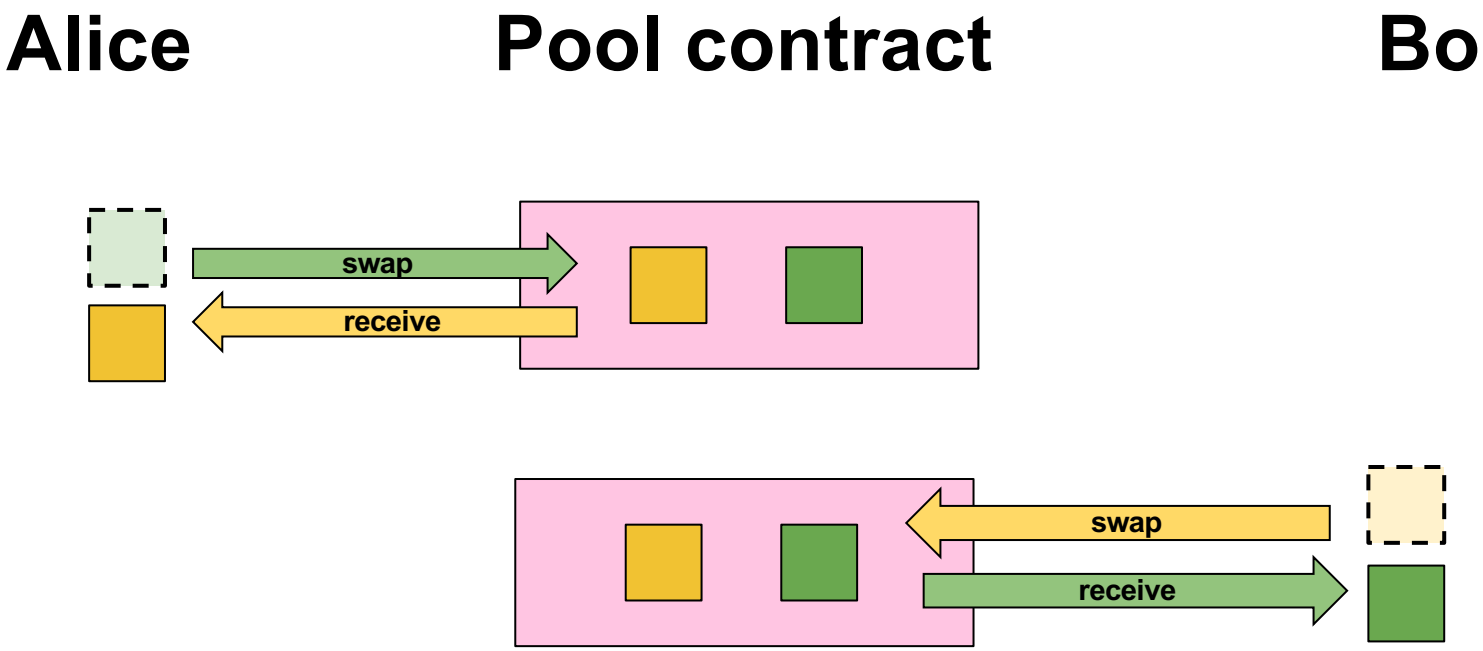
Uniswap Mechanics: Trading

Alice **Pool contract**




```
function swap(uint amount0Out, uint amount1Out, address to, bytes calldata data) external;
```

Uniswap Mechanics: Trading

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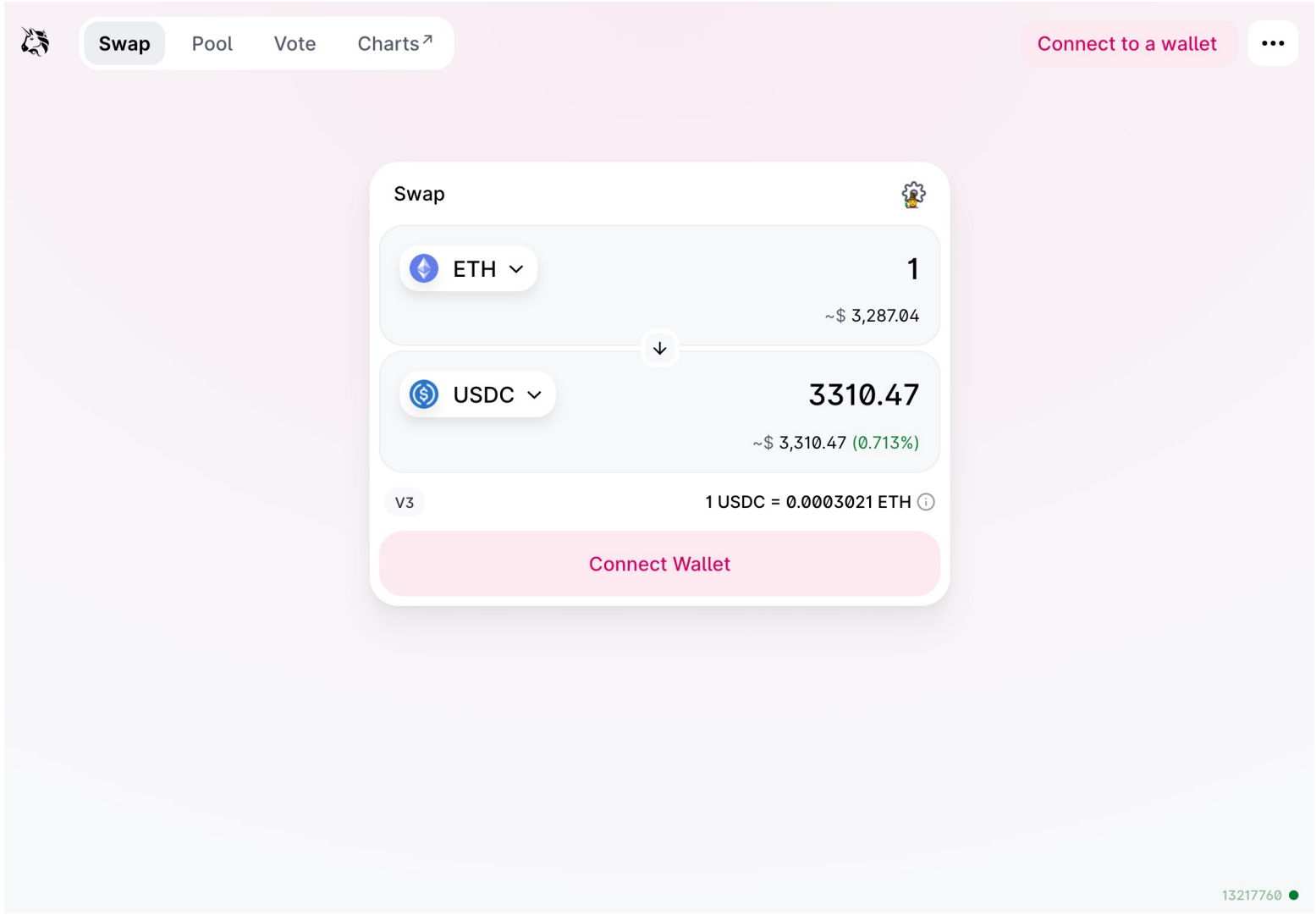
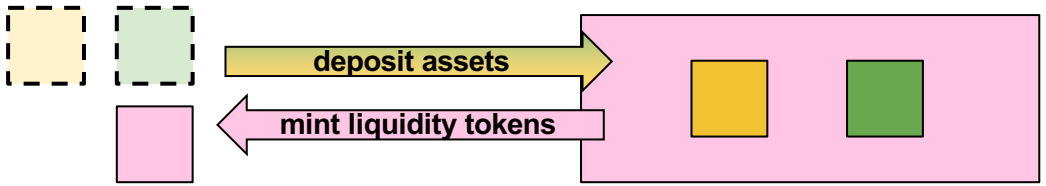


Uniswap Mechanics: Adding Liquidity

Liquidity provider

Pool contract

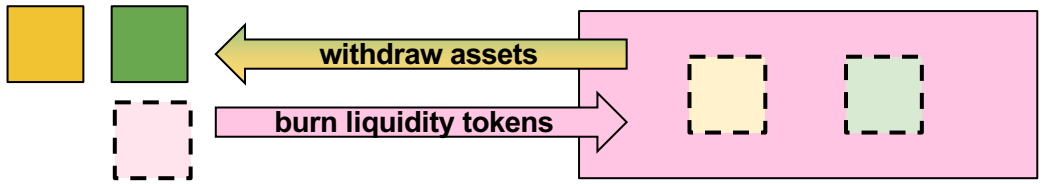



```
function mint(address to) external returns (uint liquidity);
```

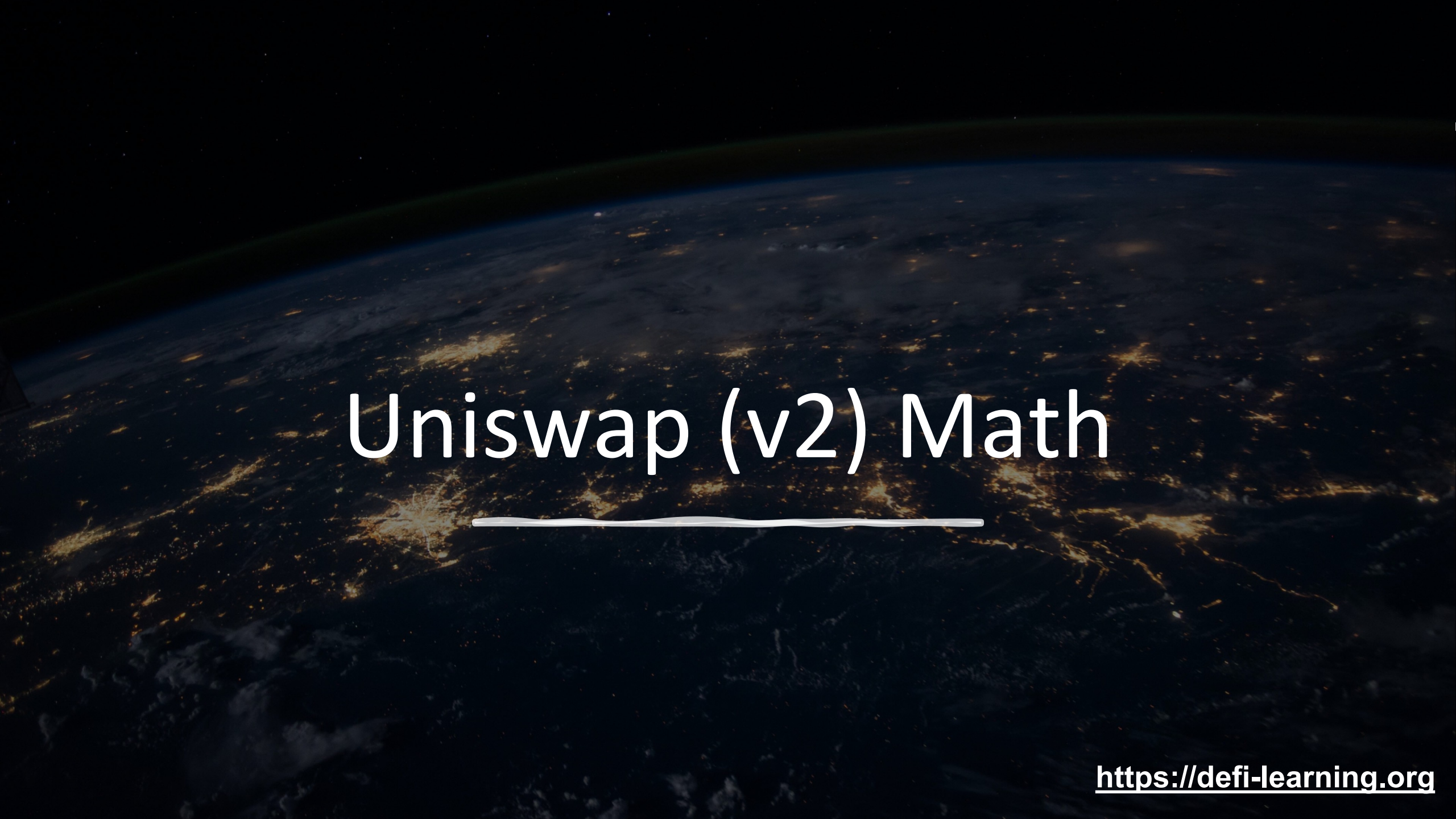
Uniswap Mechanics: Removing Liquidity

Liquidity provider

Pool contract




```
function burn(address to) external returns (uint amount0, uint amount1);
```


Uniswap (v2) Math
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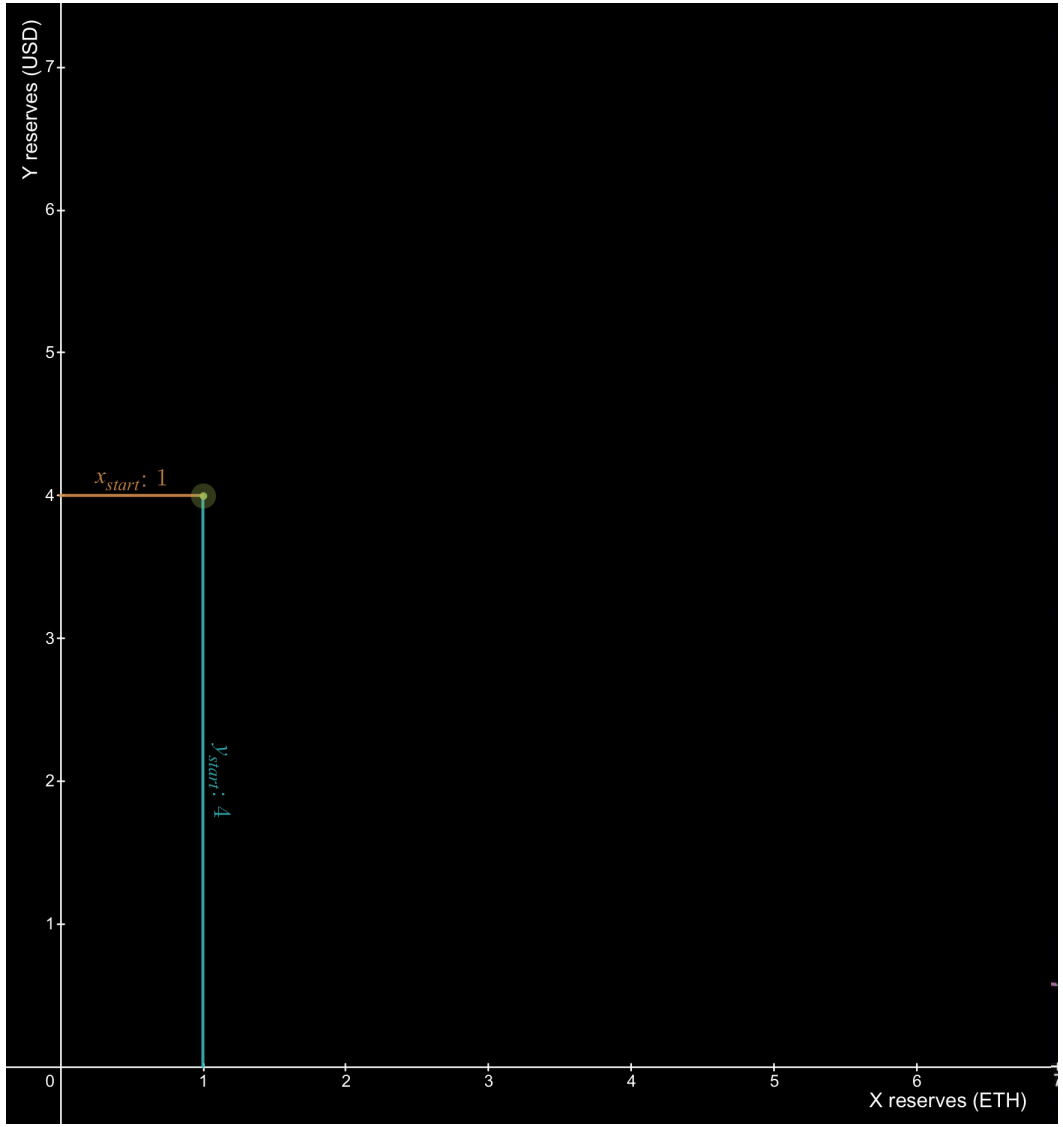

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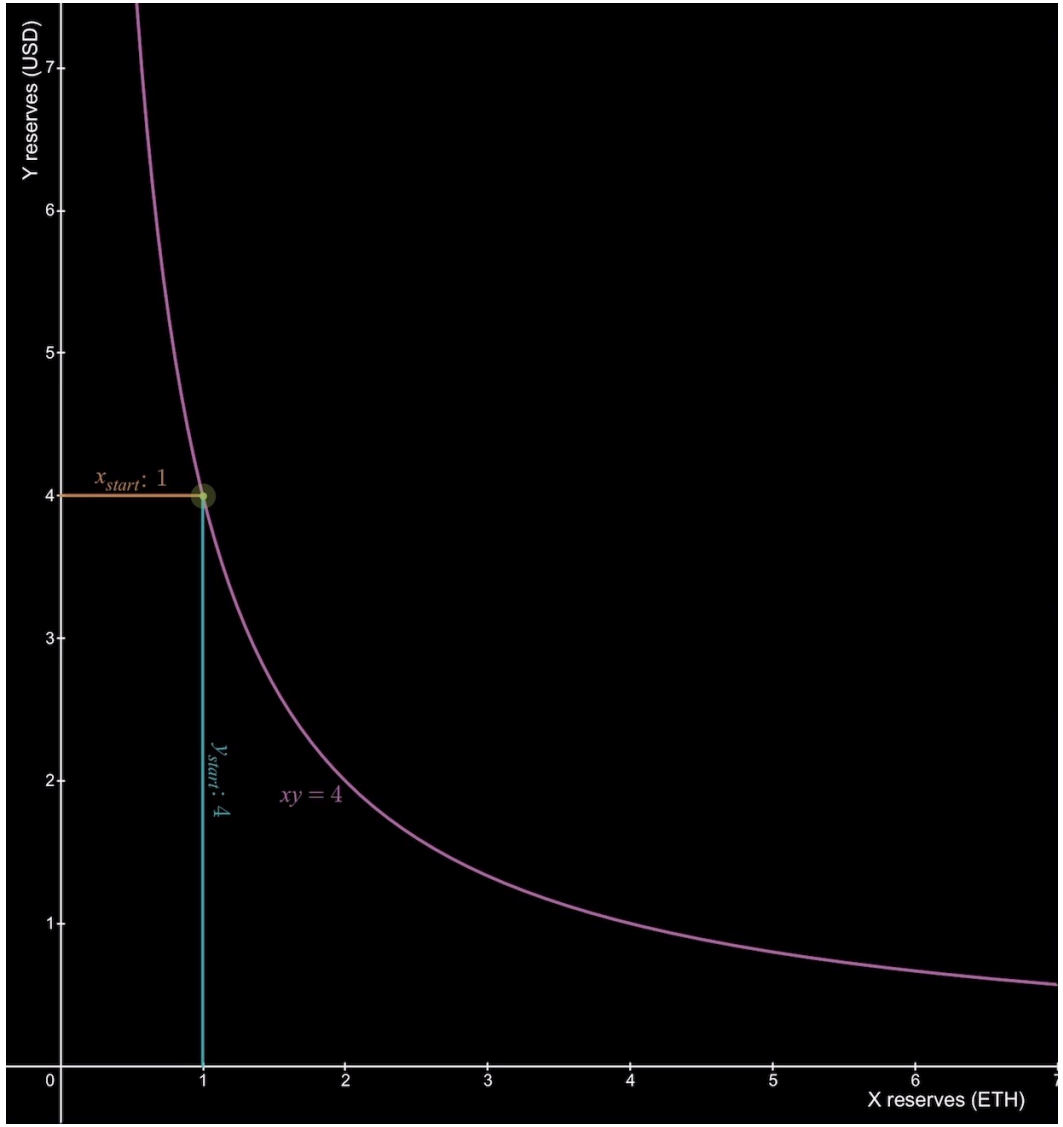
Uniswap (v2) Math



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Uniswap (v2) Math

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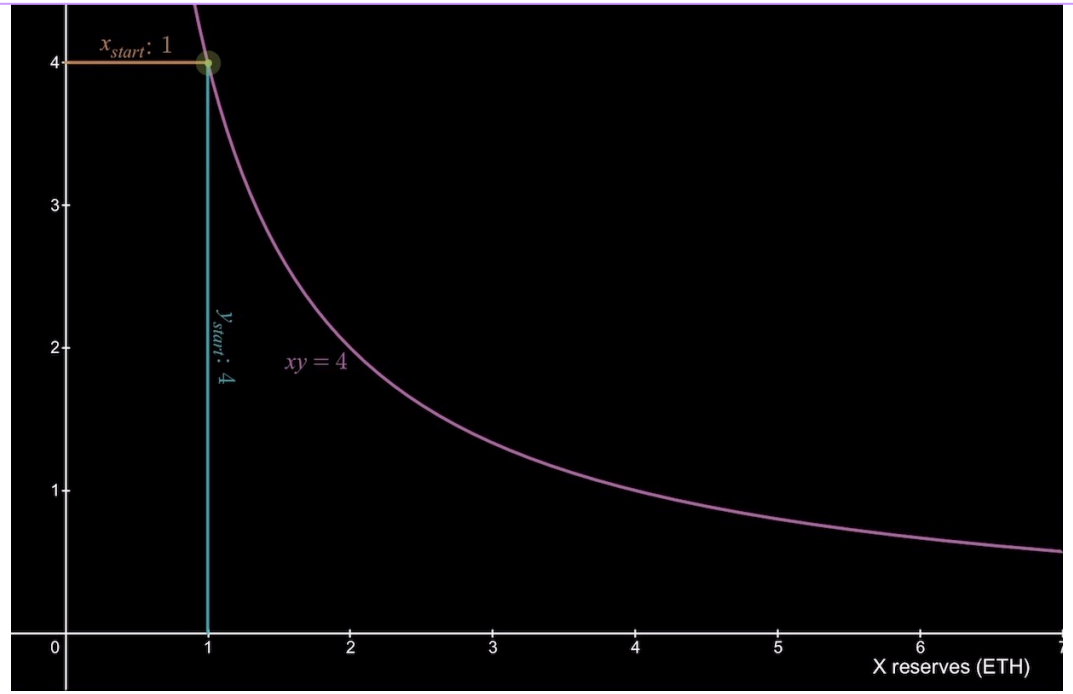
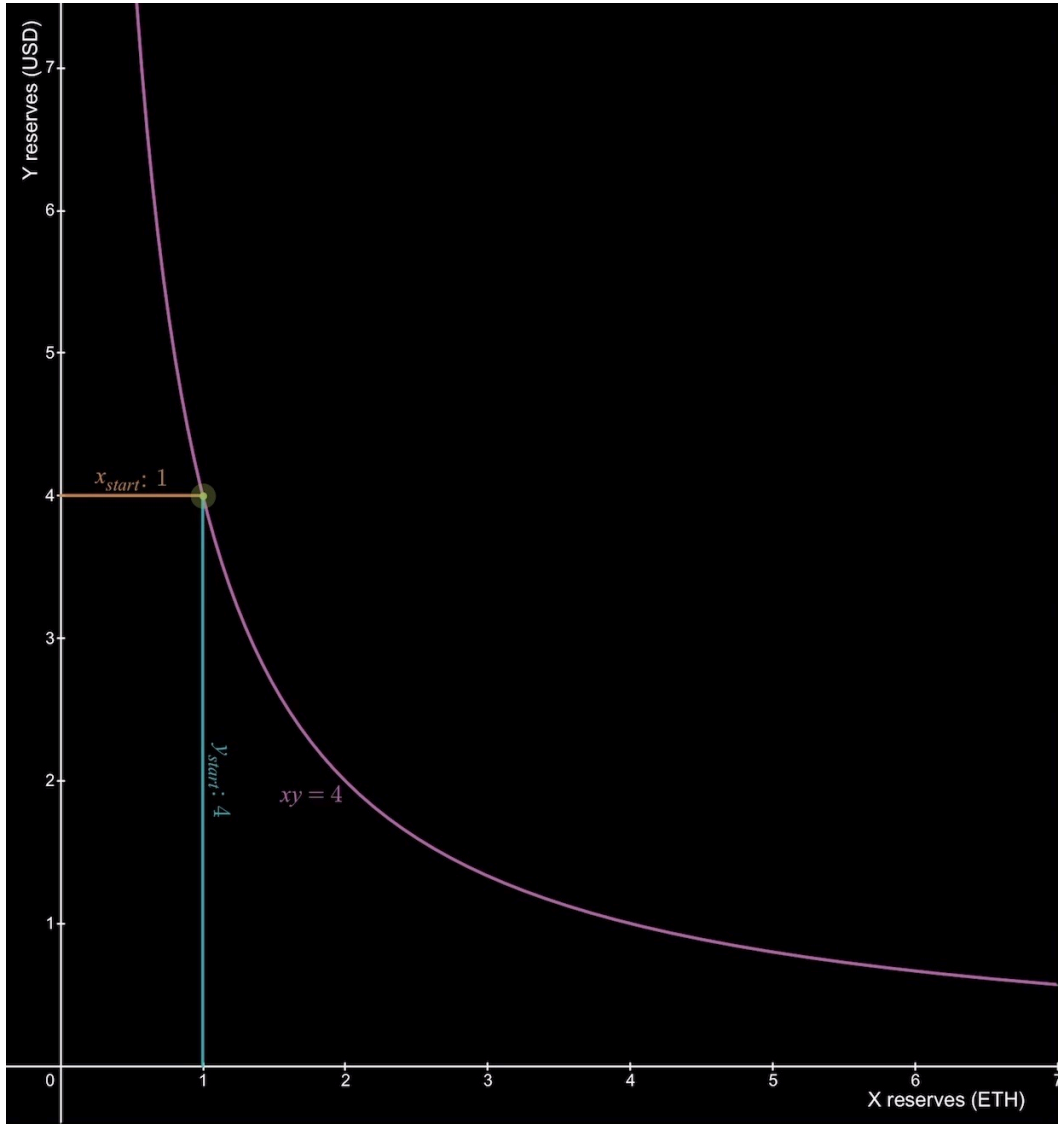
```
require(balance0Adjusted.mul(balance1Adjusted) >= uint(_reserve0).mul(_reserve1).mul(1000**2), 'UniswapV2: K');
```



Uniswap (v2) Math



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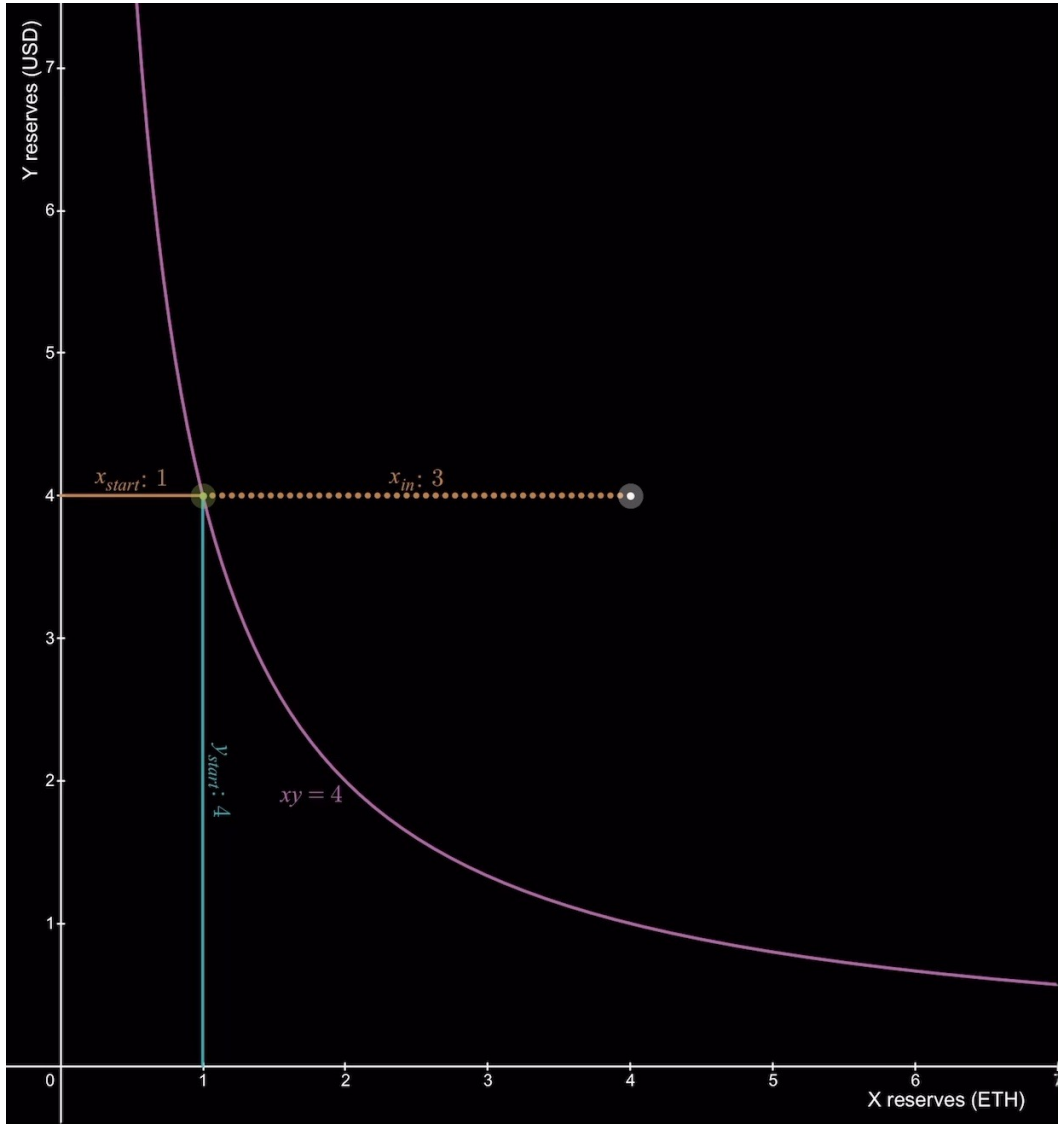

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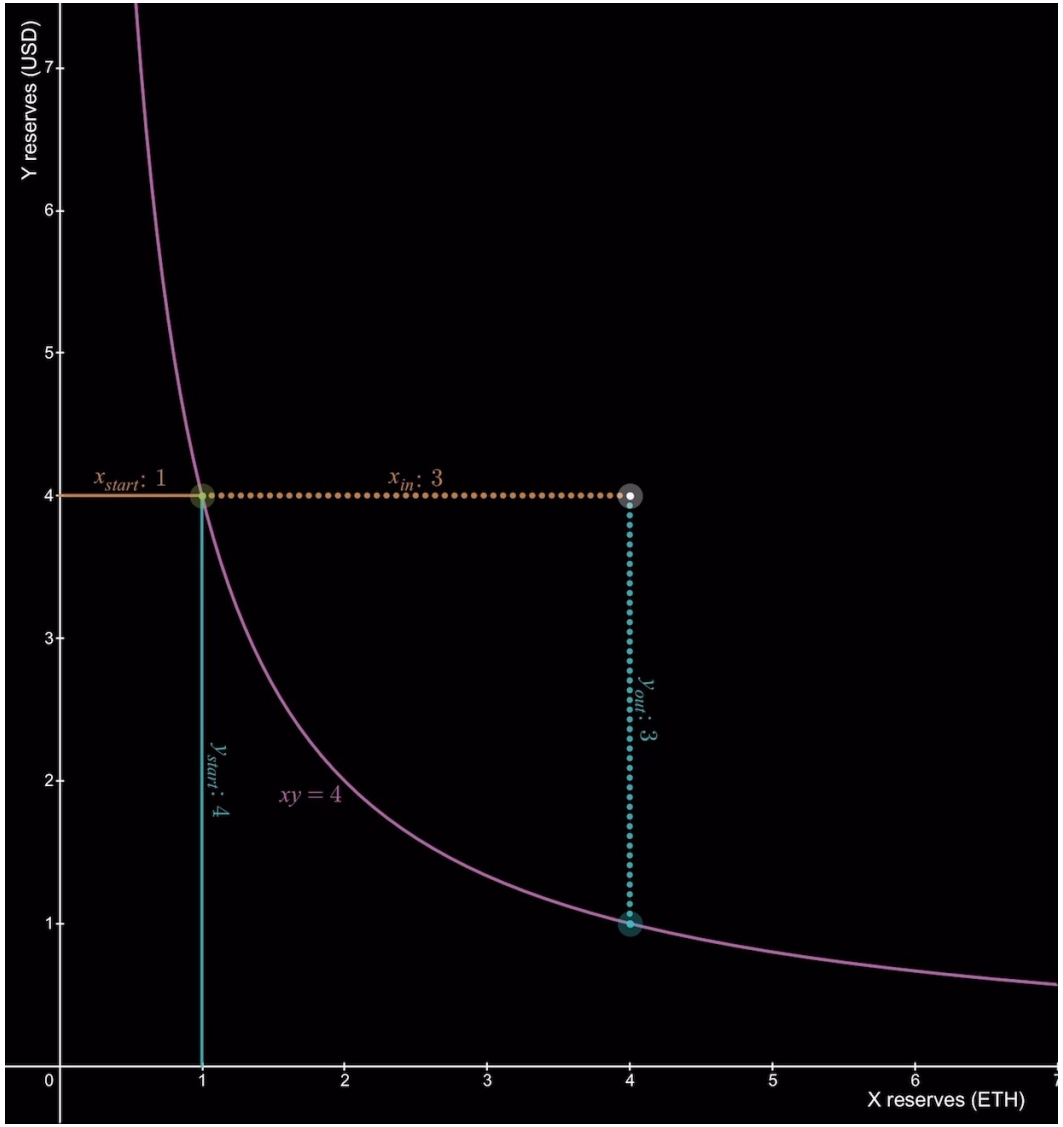

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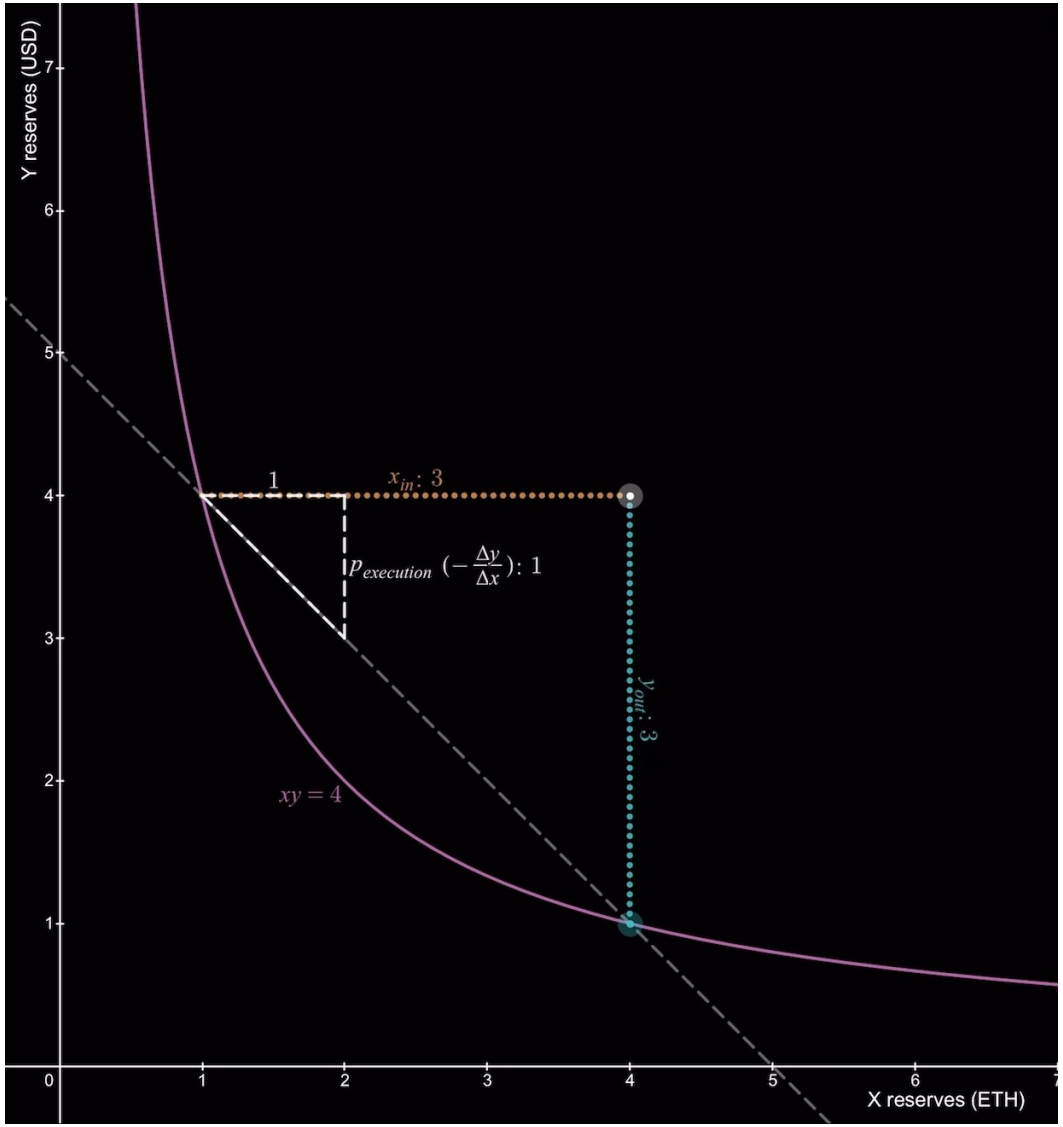

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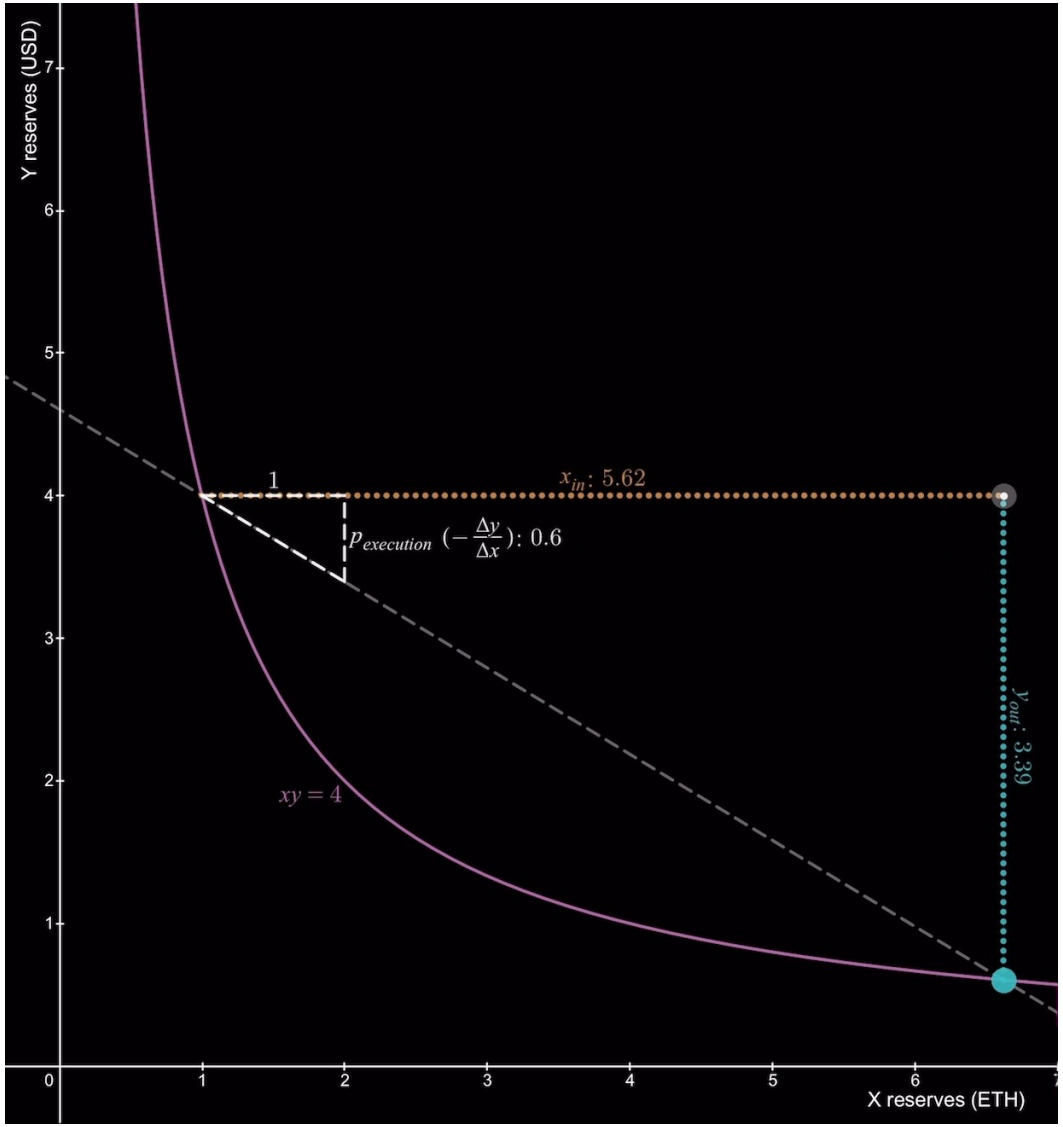

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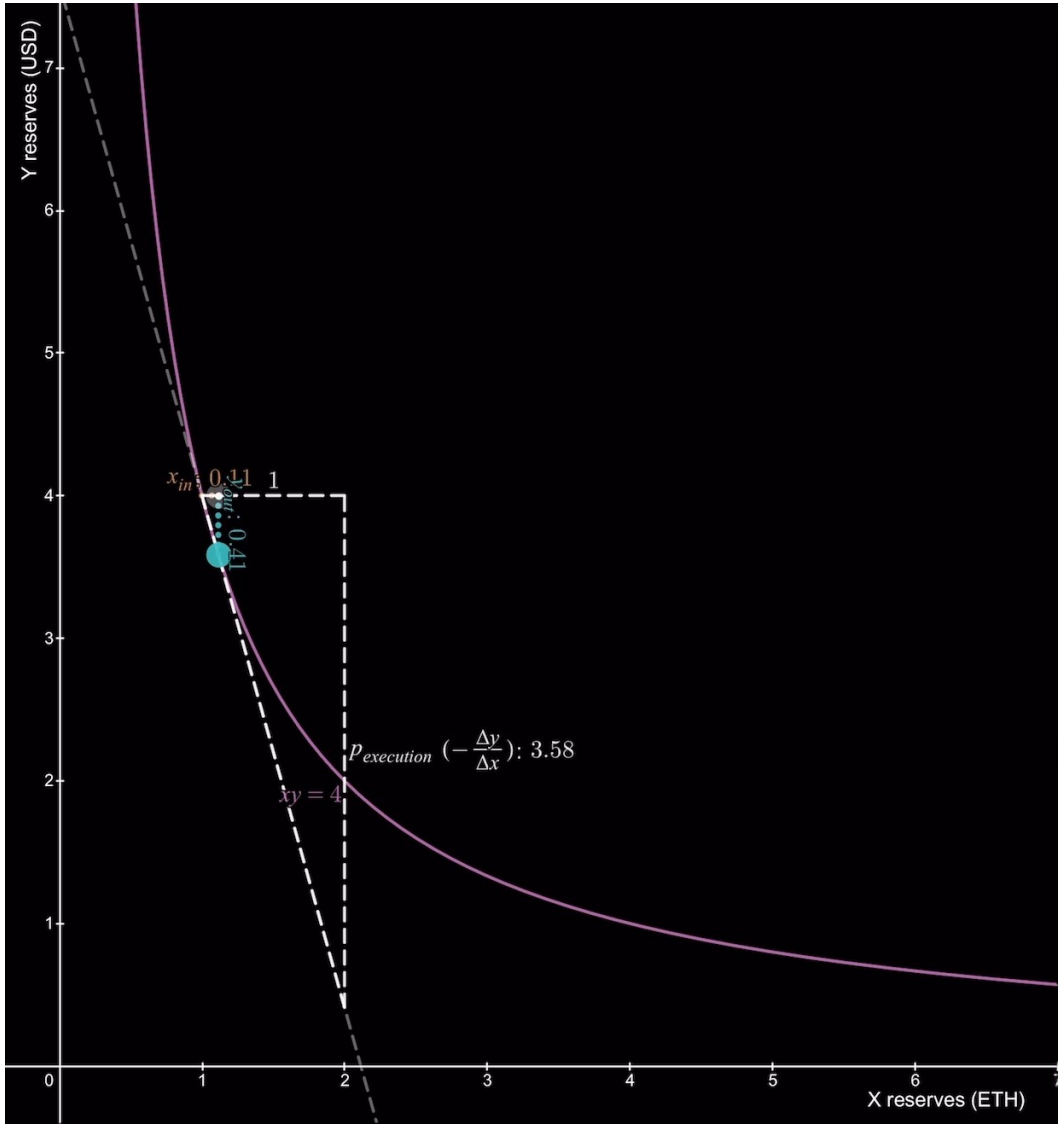

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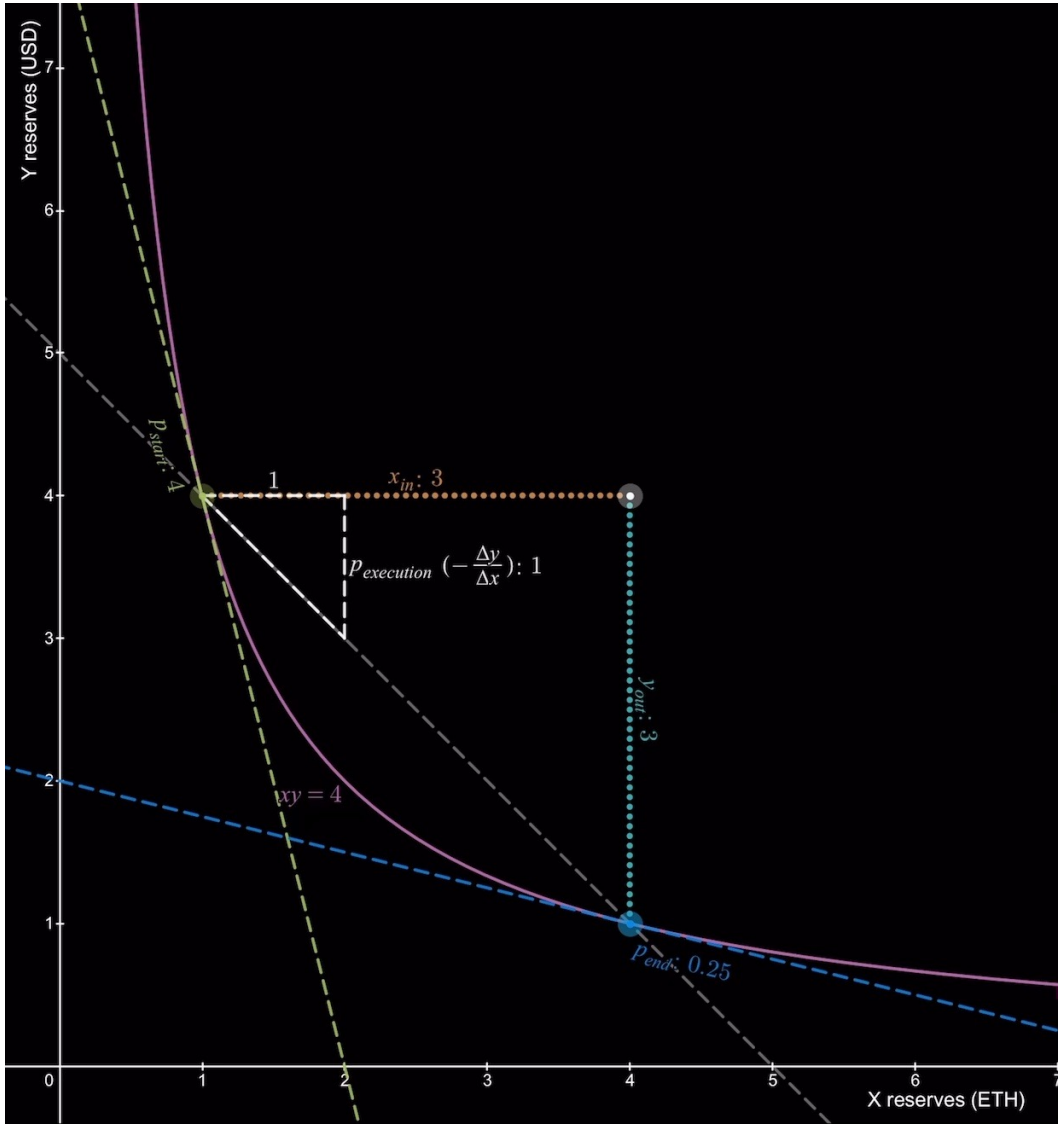

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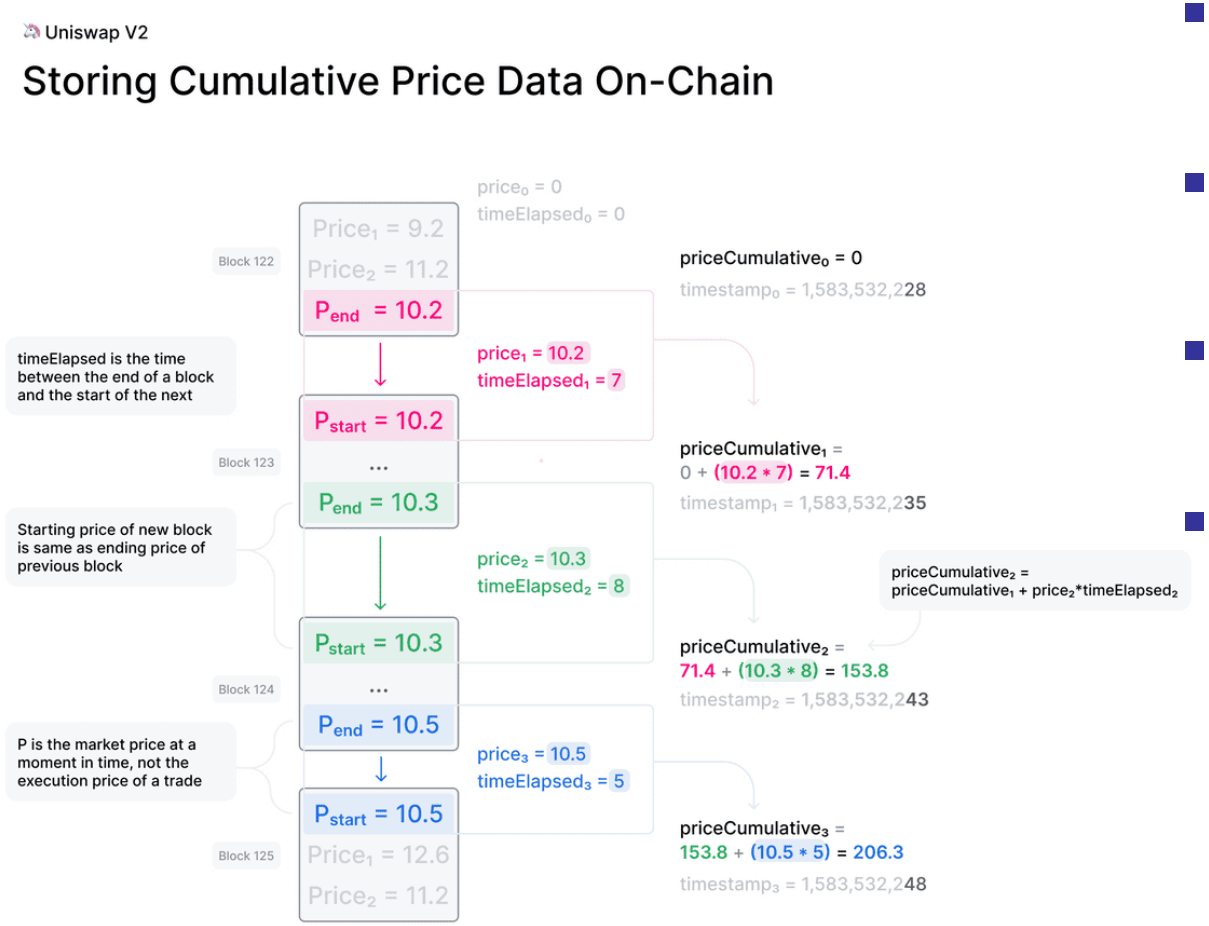
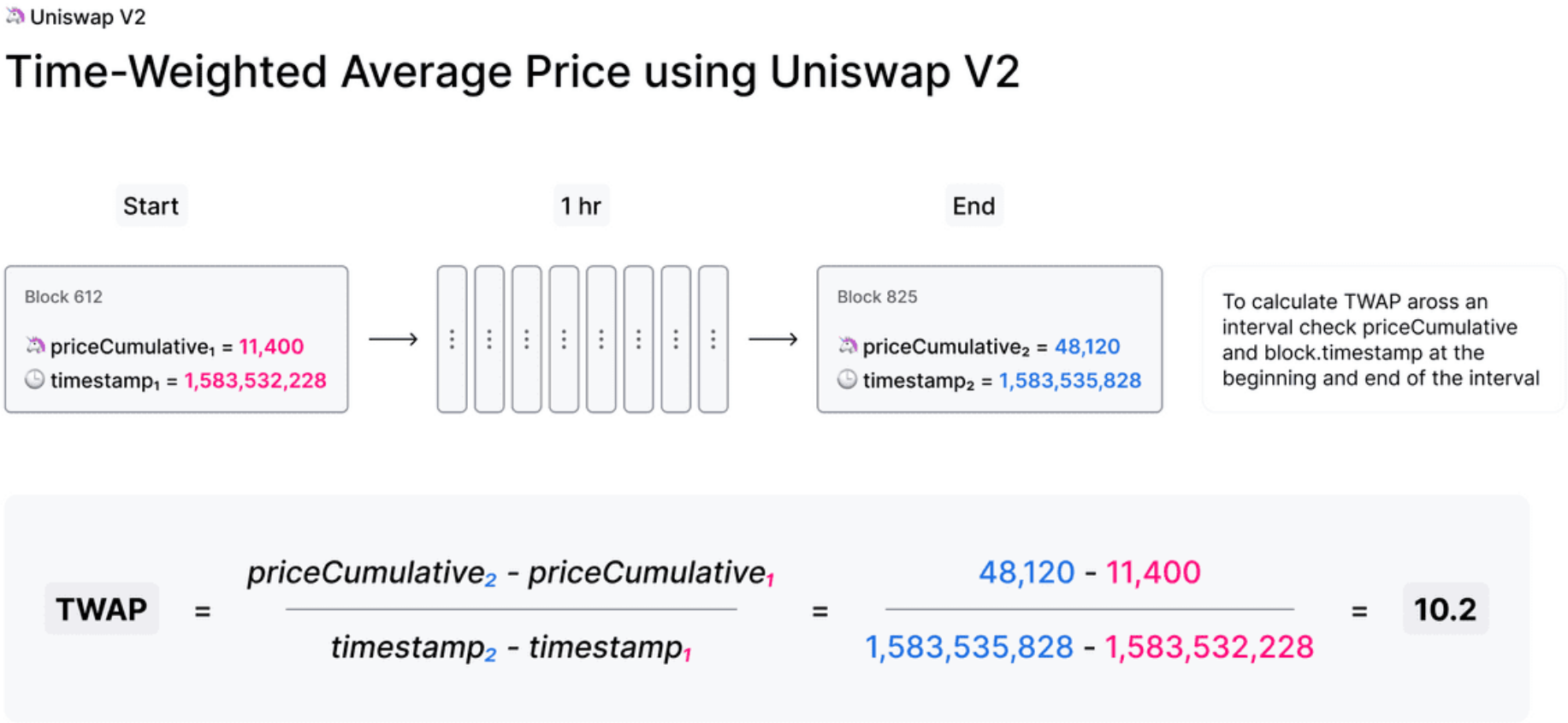
Uniswap Mechanics: Price Oracle

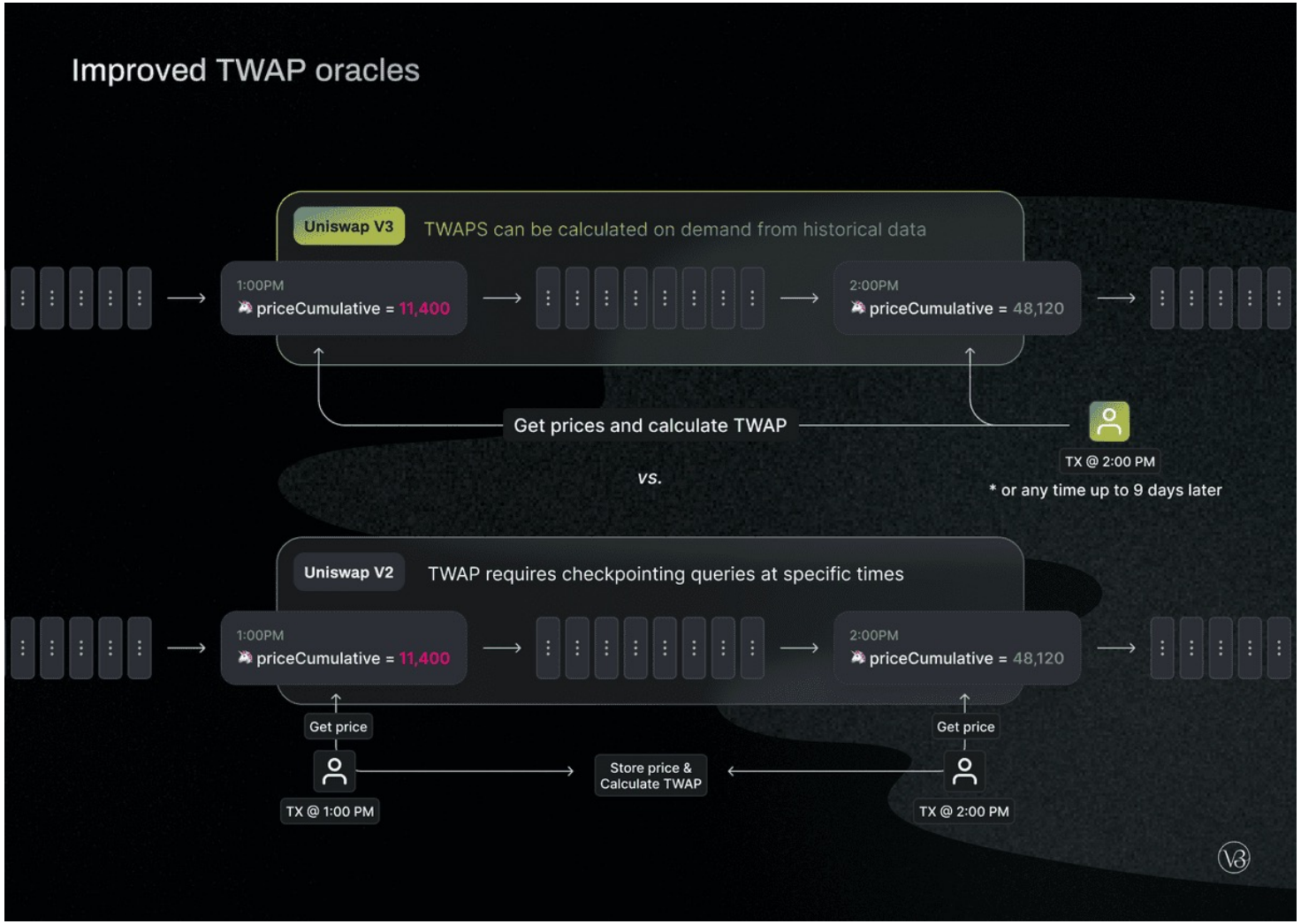


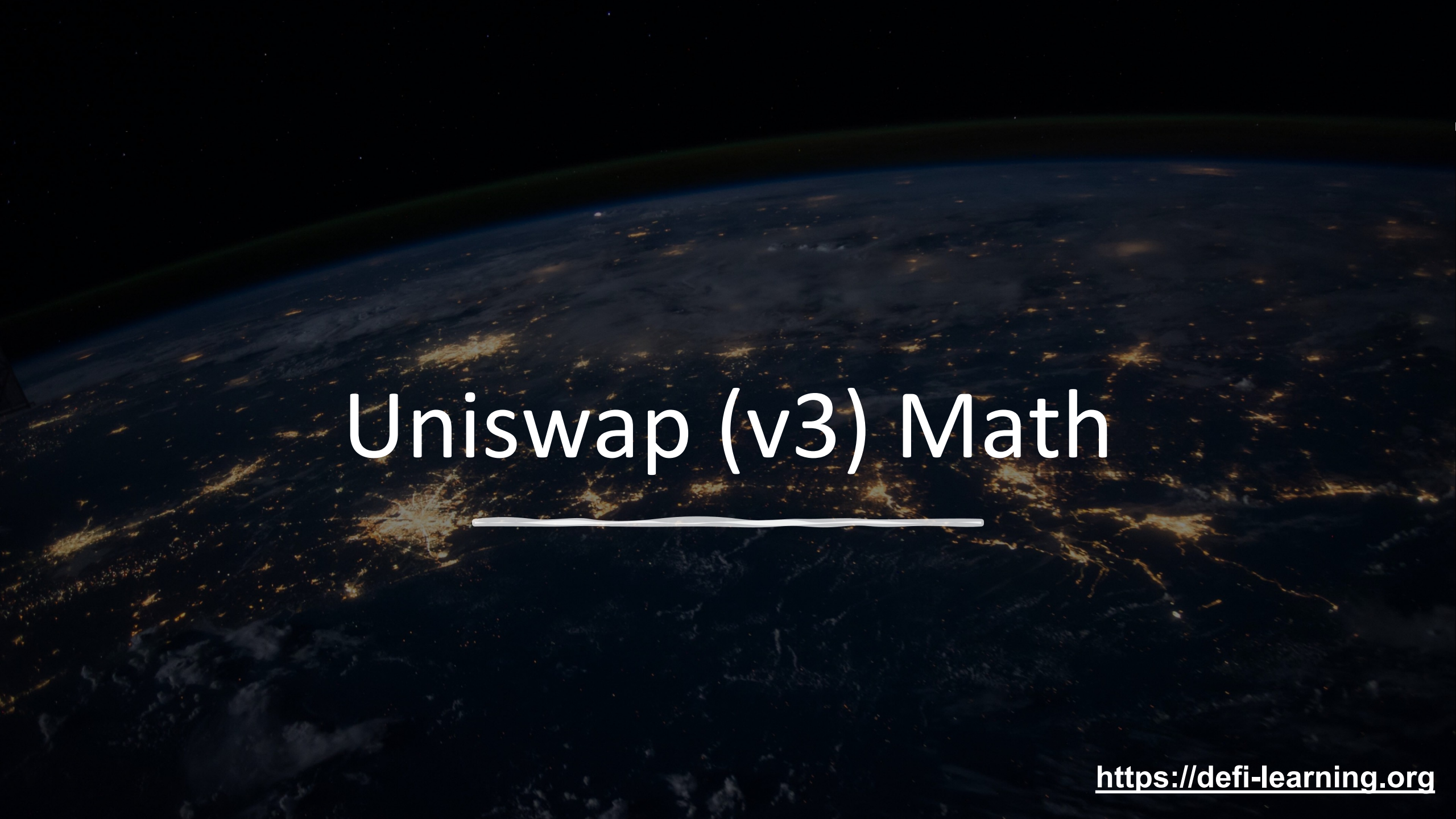
- Many DeFi applications (like synthetics and lending protocols) depend on **price oracles**
- Uniswap can be used as this price oracle for ERC-20 tokens
- But just using the current price is vulnerable to a **sandwich attack**
- To mitigate this, Uniswap v2 and v3 track an accumulator that allows computation of a **time-weighted average price** (TWAP) over many blocks

Uniswap Mechanics: Price Oracle (v2)



Uniswap Mechanics: Price Oracle (v3)

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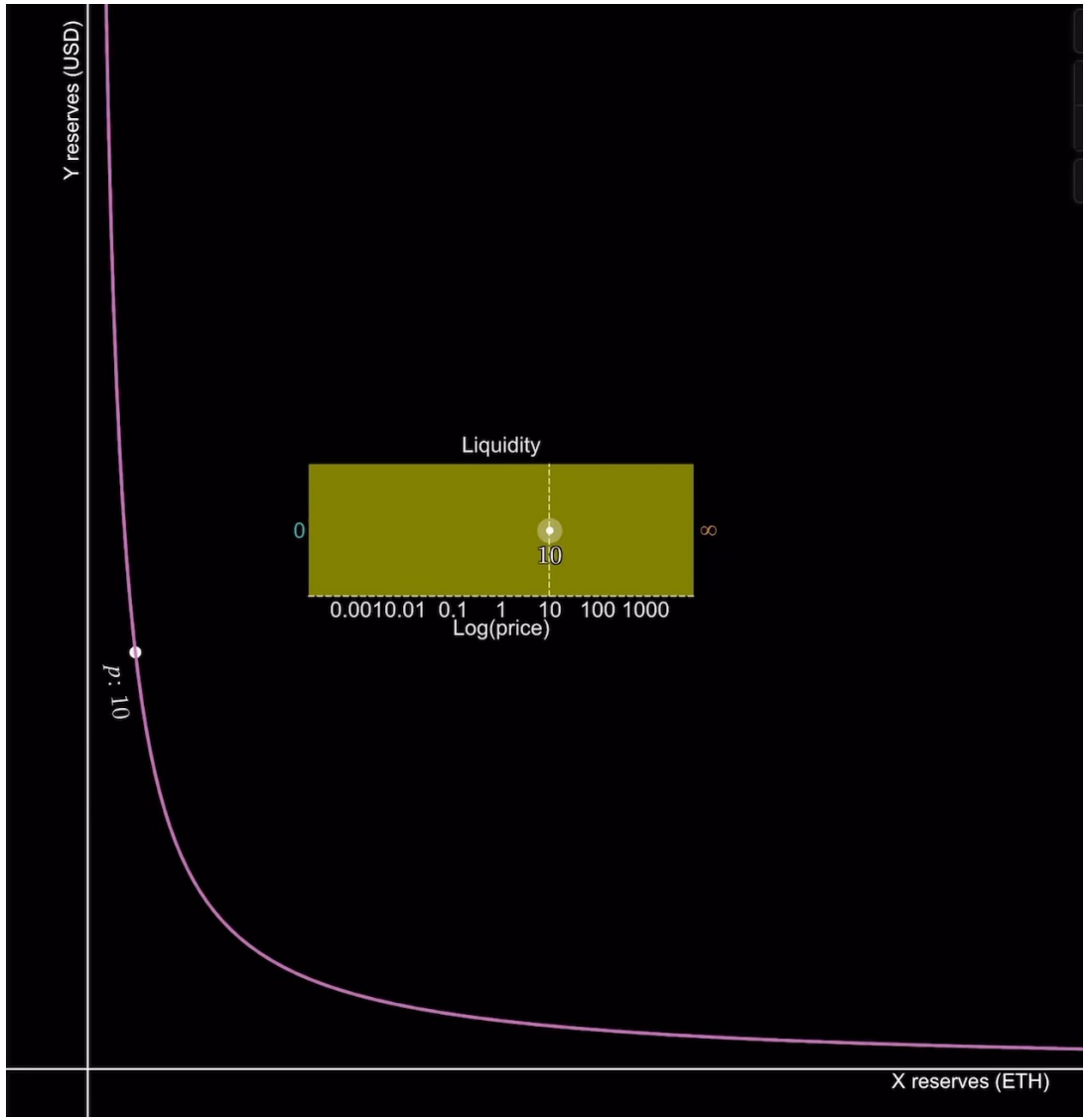
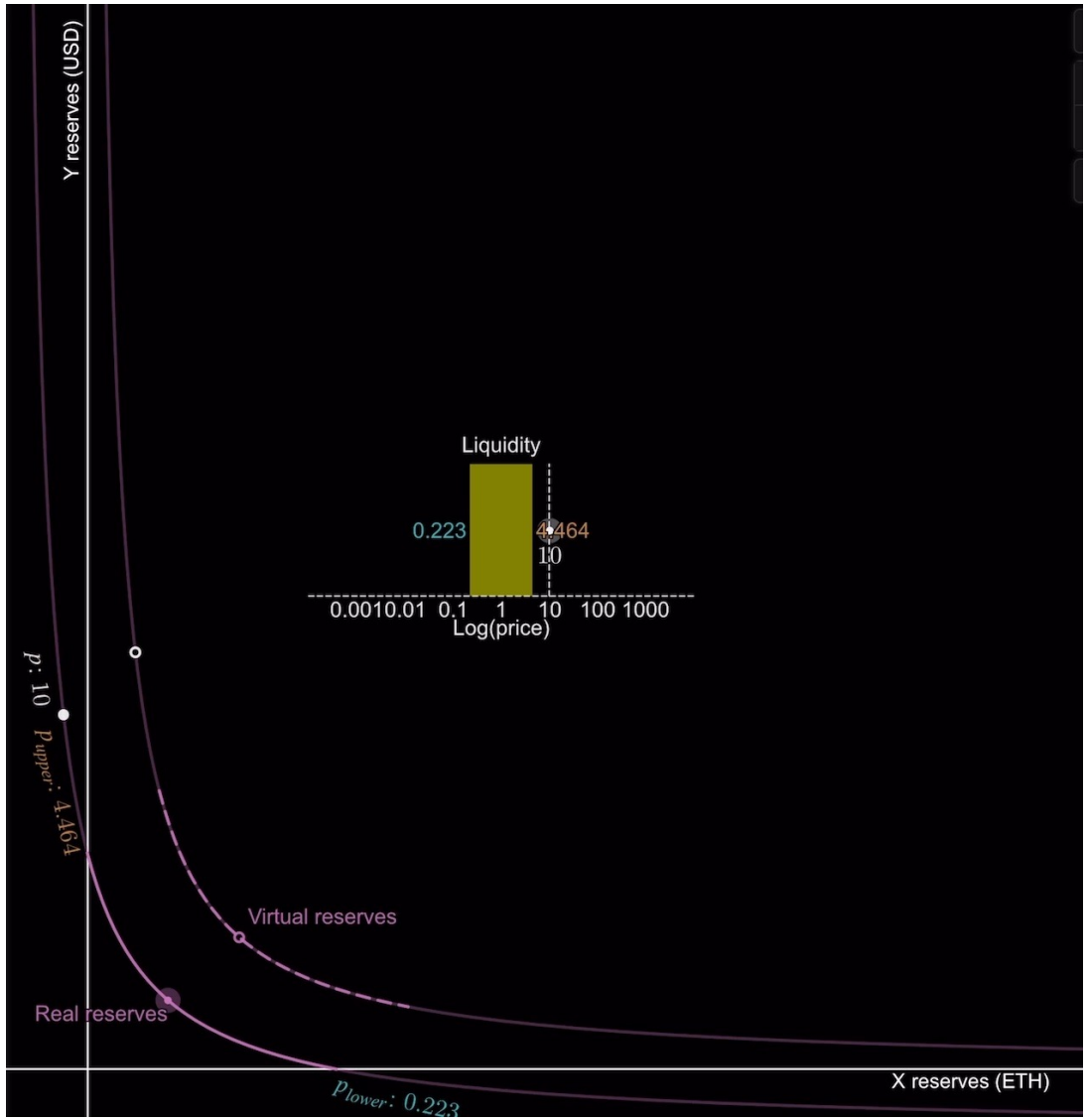


- In Uniswap v2, some reserves are saved for all possible prices, which is capital inefficient

Uniswap (v3) Math



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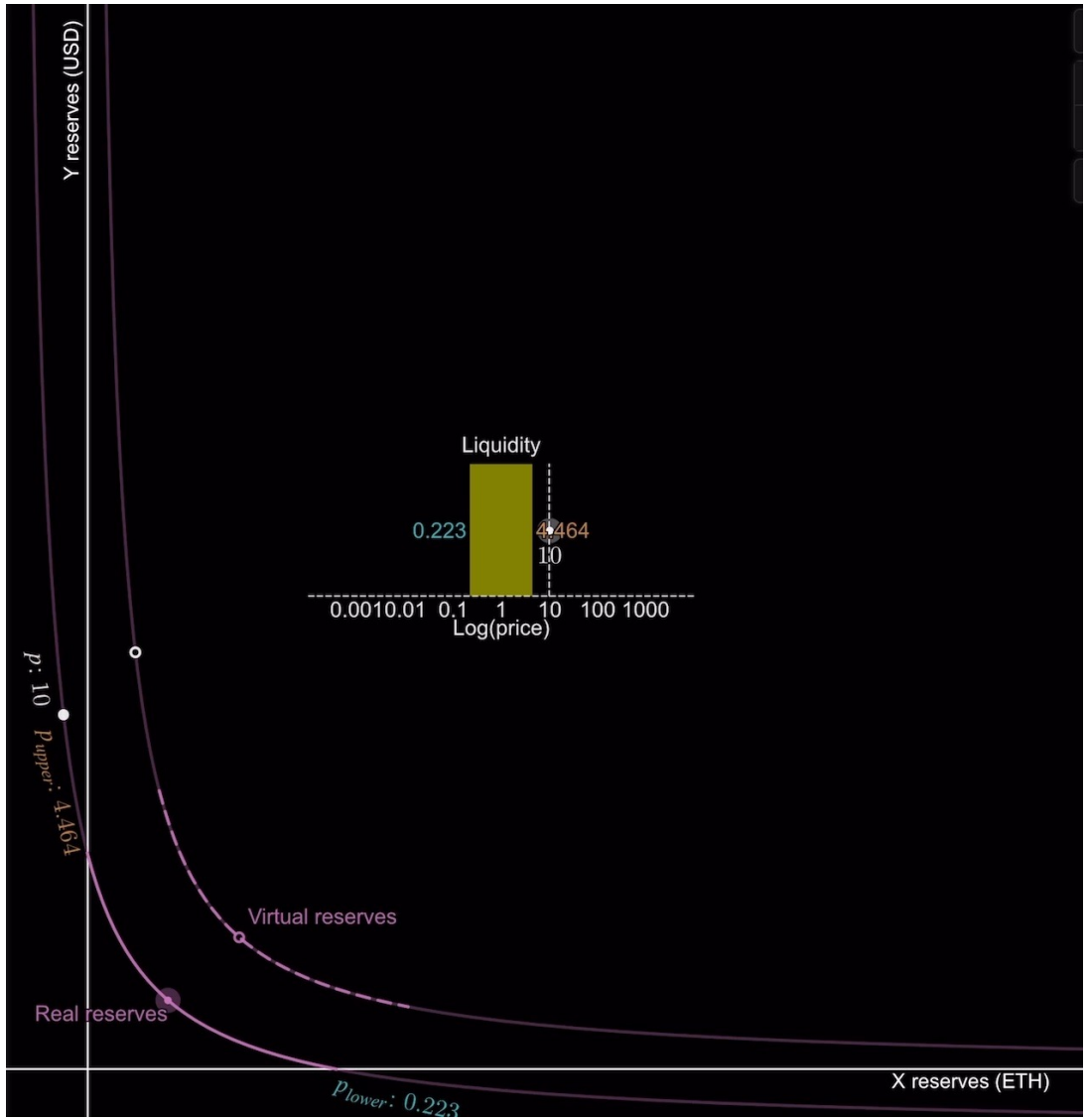
Uniswap (v3) Math



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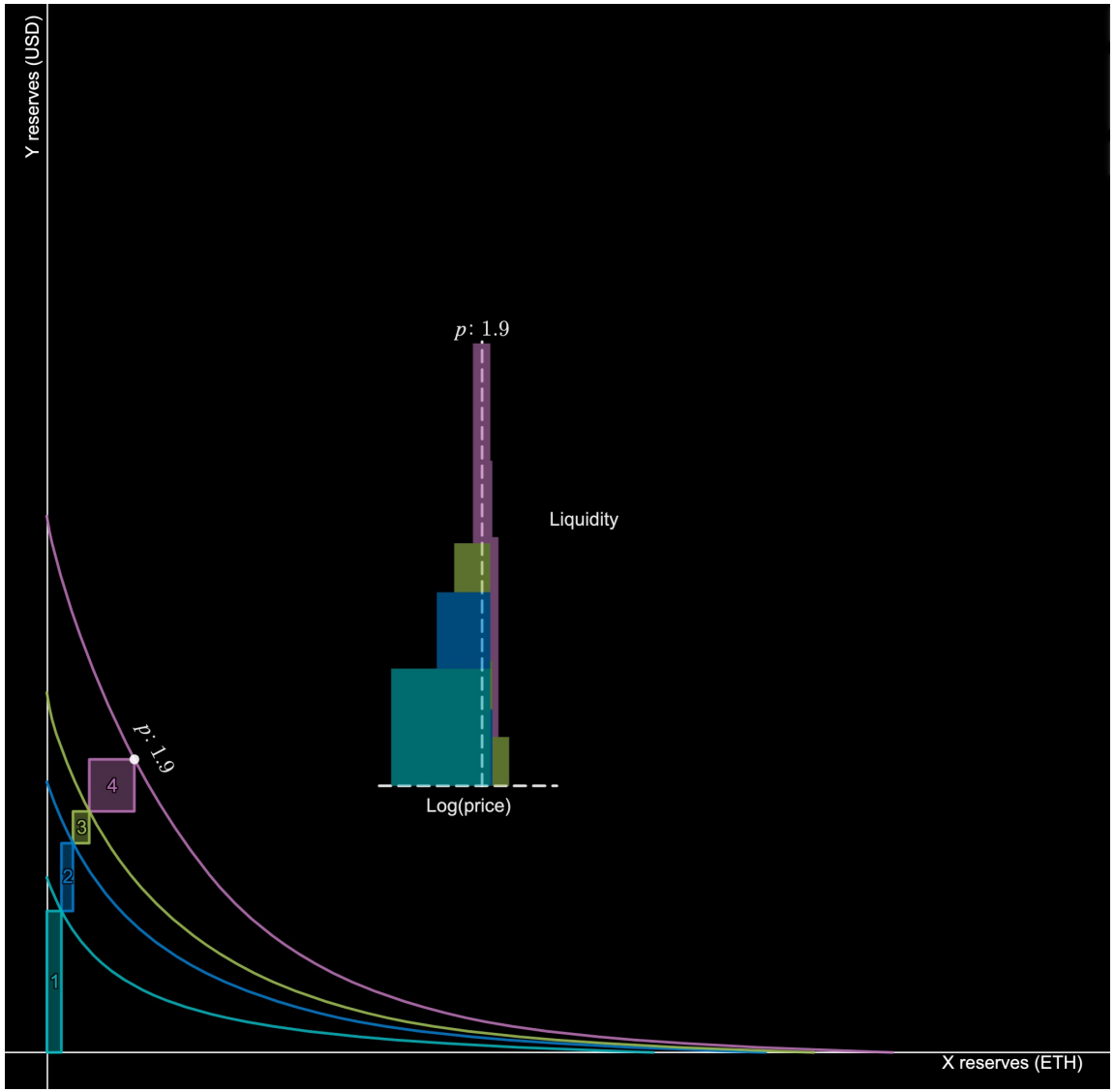

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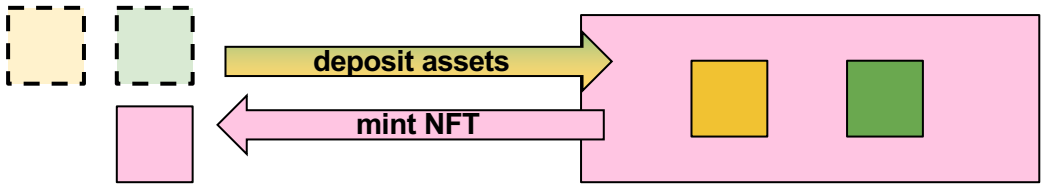
- Uniswap v3 allows liquidity providers to add **concentrated liquidity** within a specific price range
- This is equivalent to translating the **xy = k** curve down and to the left
- Different liquidity providers can provide liquidity in custom ranges, which is all aggregated together into the same pool

Uniswap (v3) Mechanics: Adding Liquidity

Liquidity provider

Pool contract



Links

- Uniswap v2 Whitepaper
  - https://uniswap.org/whitepaper.pdf
- Uniswap v3 Whitepaper
  - https://uniswap.org/whitepaper-v3.pdf
- The graphs above are interactive visualizations on Desmos
  - https://docs.uniswap.org/protocol/concepts/advanced/resources

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