

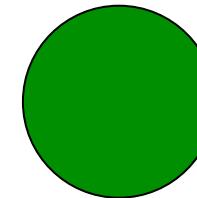
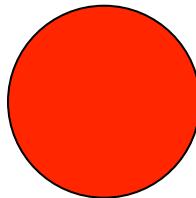
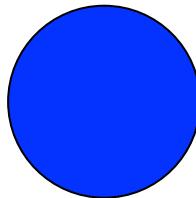
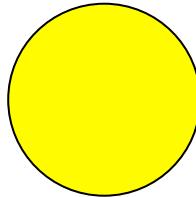
Exploring Optimization Strategies for *Mastermind*

Gioia Dominedò • Amy Lee • Kendrick Lo • Reinier Maat

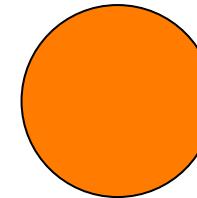
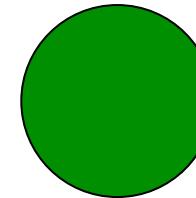
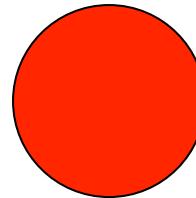
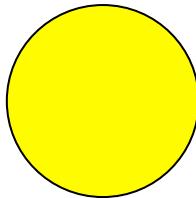
AM207 Final Project (2016)

MASTERMIND

Hidden code:



Example guess:



Response:

1 x ● 2 x ○

MASTERMIND

- Popular Strategies
 - Exclude all possibilities logically (Knuth's Algorithm)
 - Random Search
- Problems with popular strategies
 - Exhaustive search
 - Time and space requirements increase exponentially as the number of colors and/or positions increase



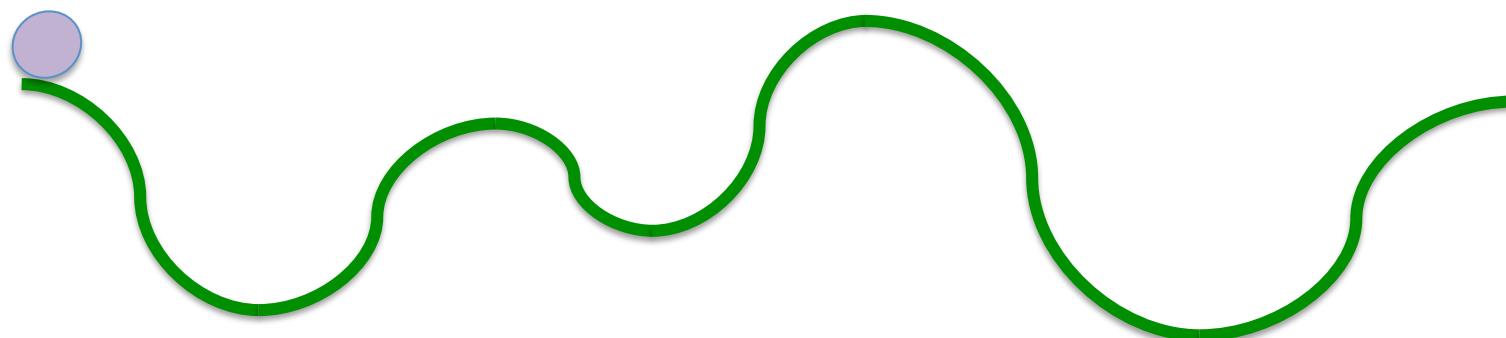
Credit: Steve Berry

TECHNIQUES EXPLORED

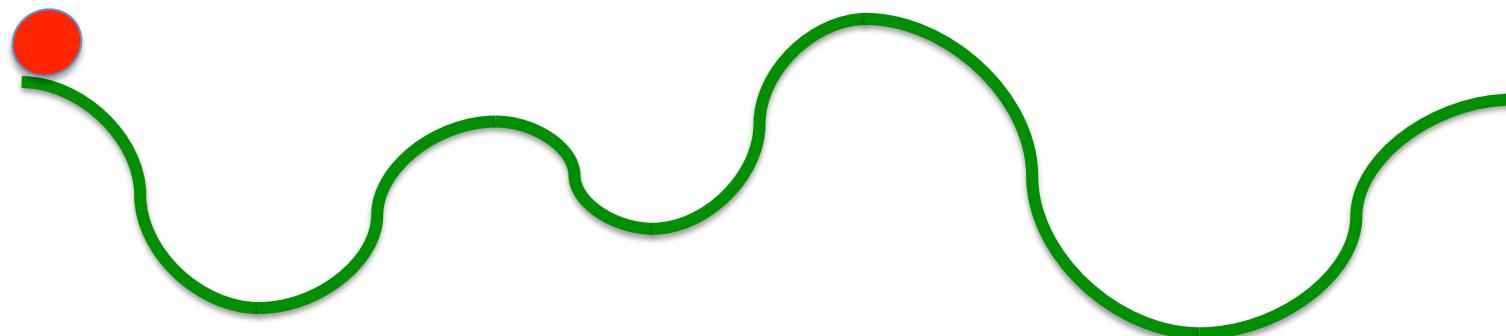
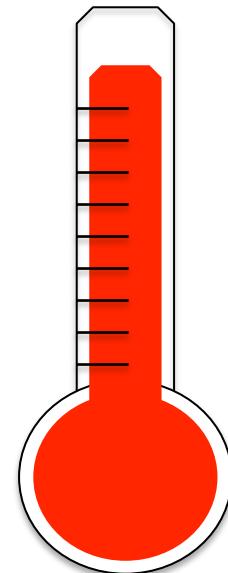
- Simulated Annealing
- Genetic Algorithms
- Expectation Maximization
- Different Objective Functions
 - E.g. entropy
- Goal:
Find a strategy that is tractable as game scales

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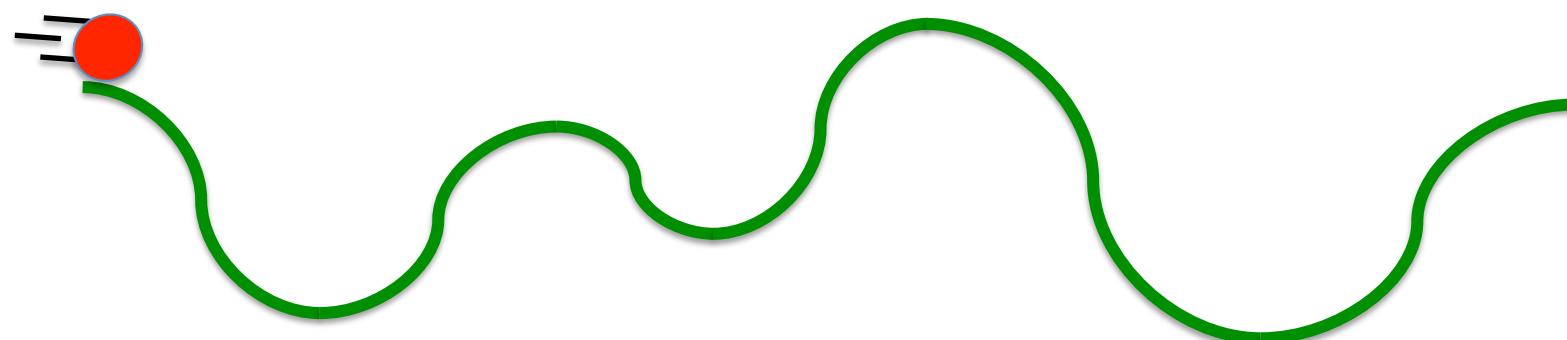
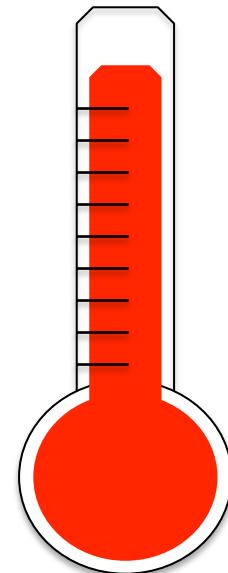
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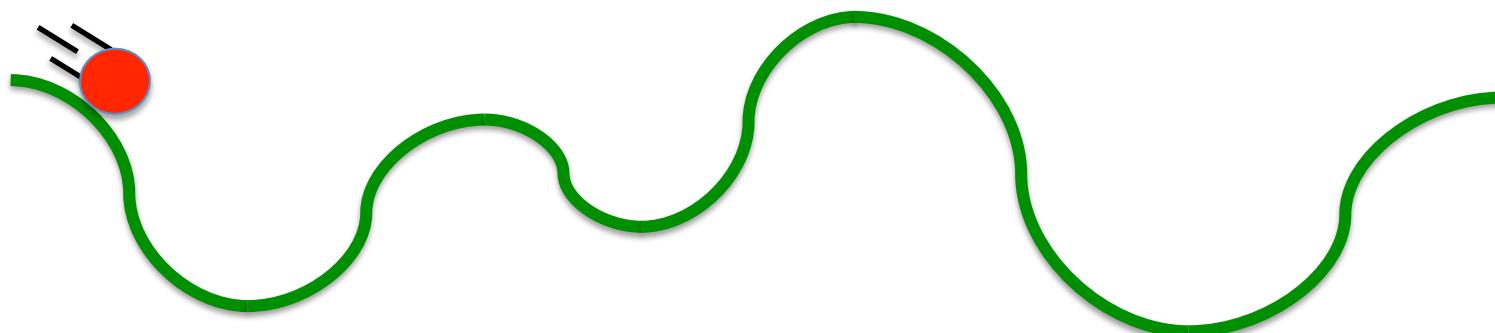
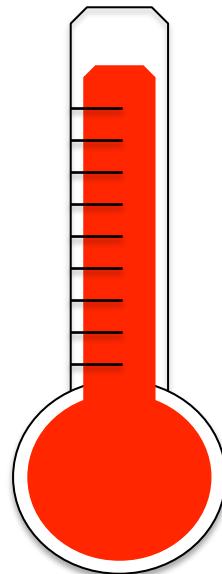
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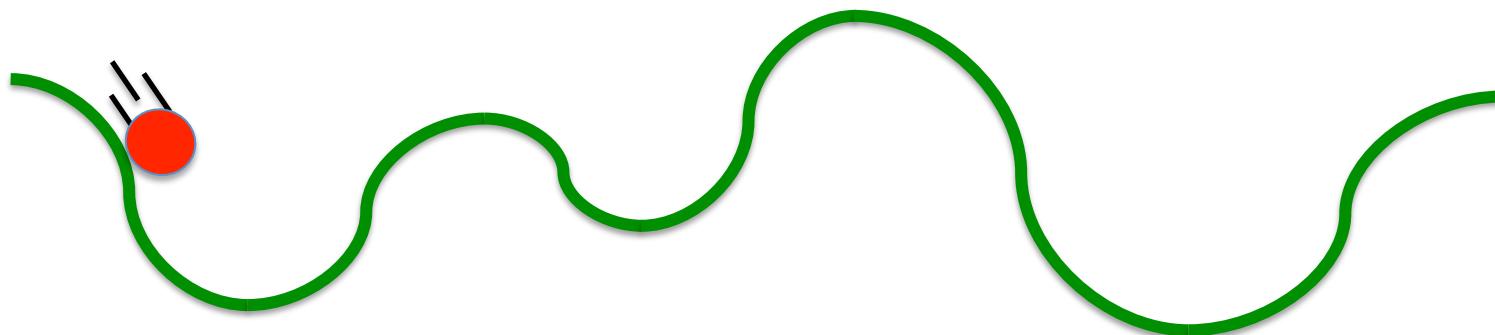
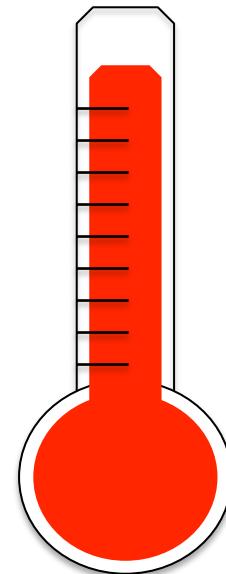
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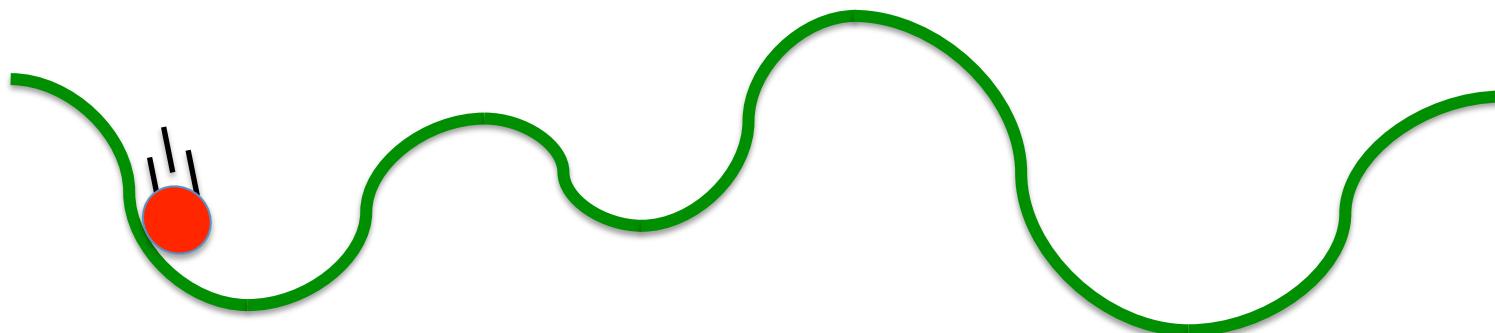
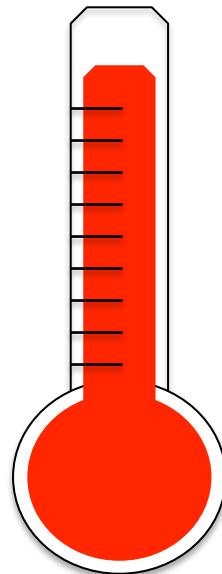
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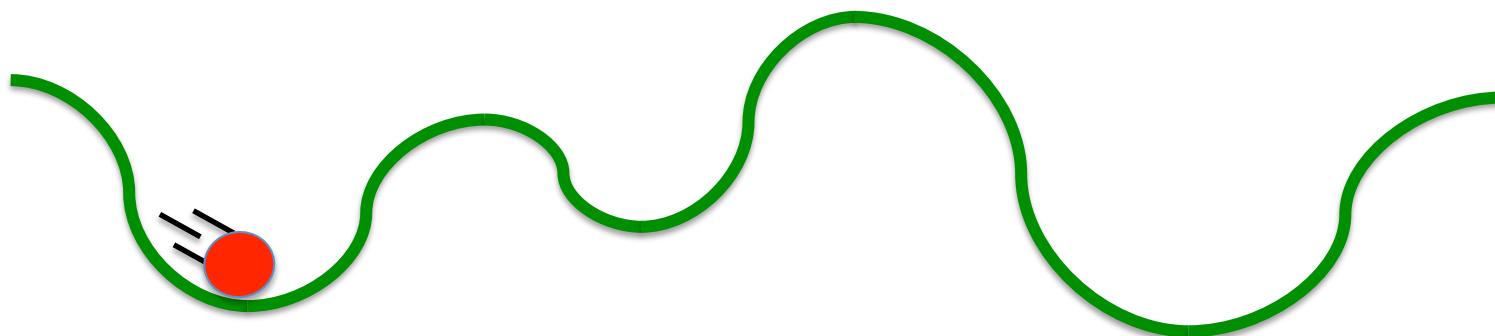
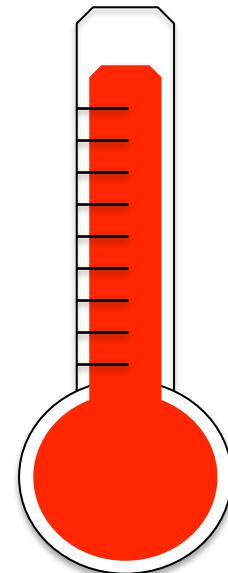
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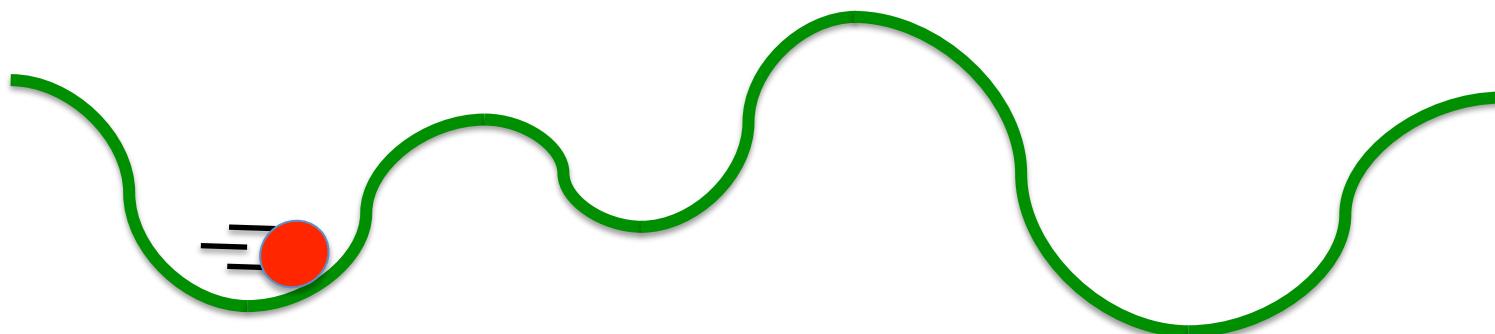
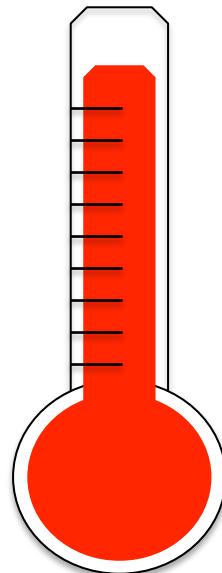
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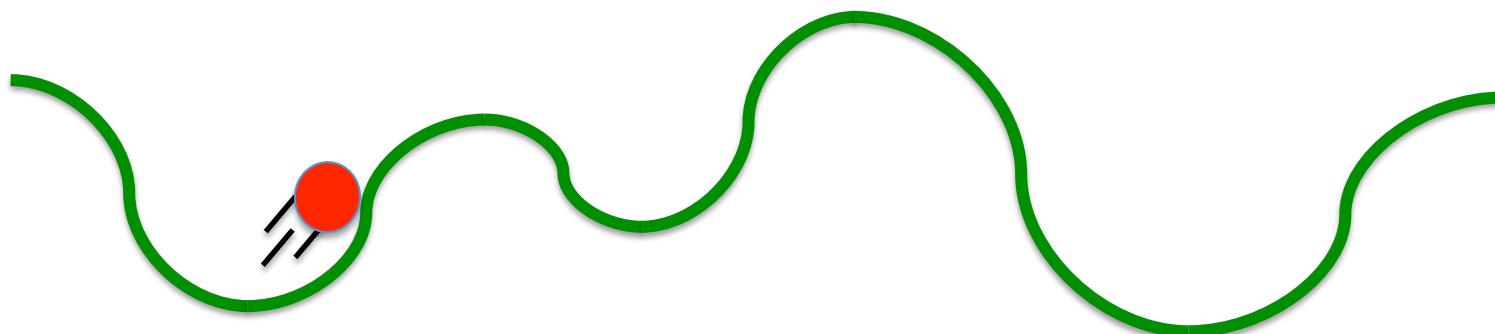
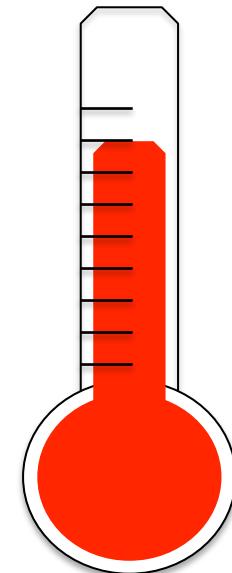
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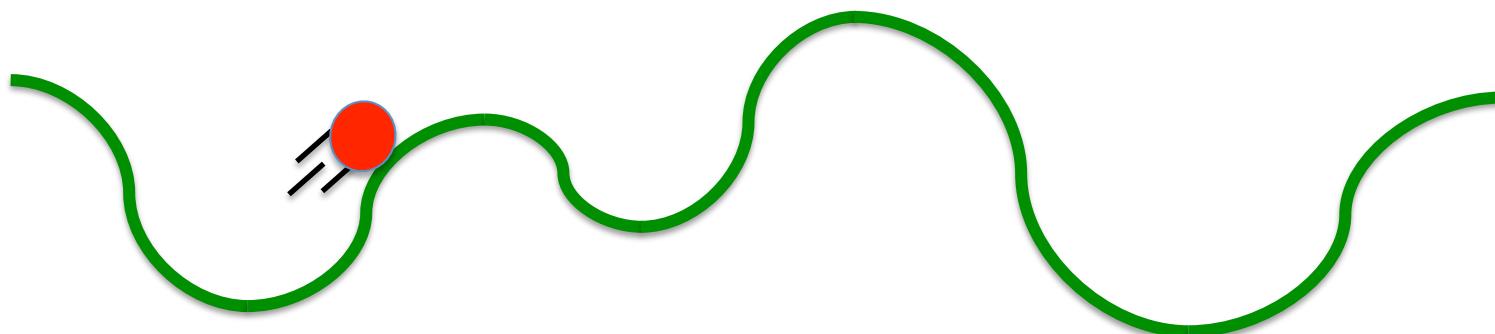
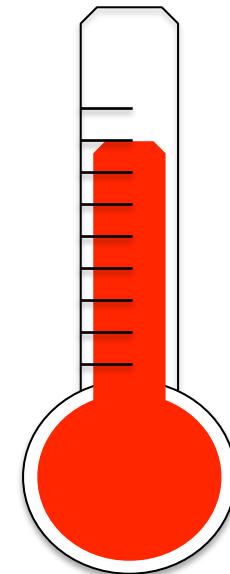
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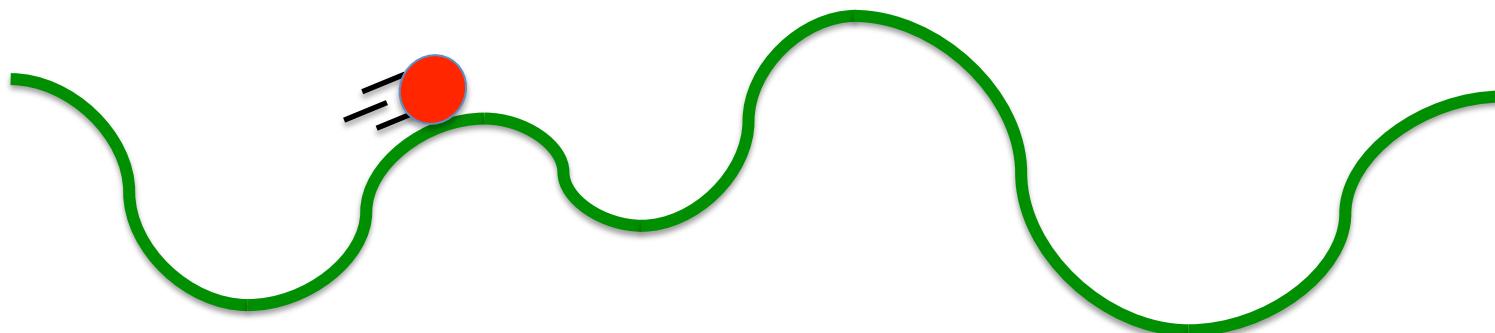
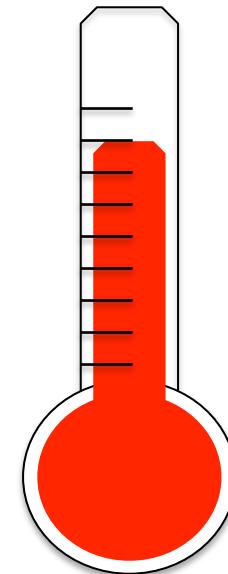
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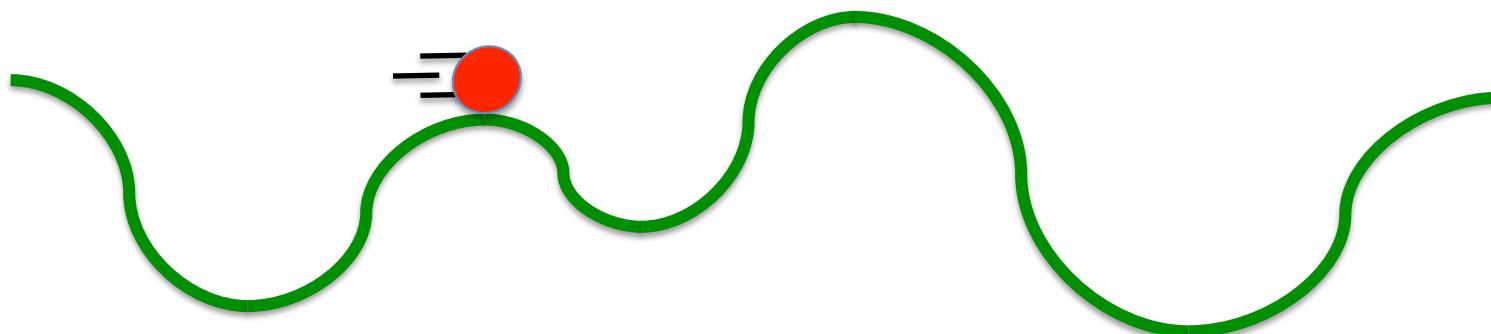
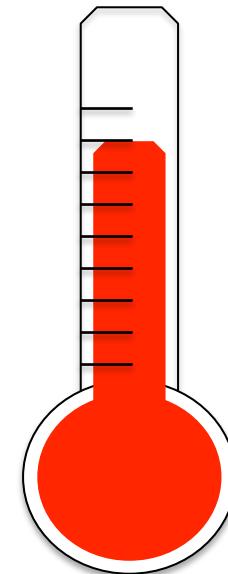
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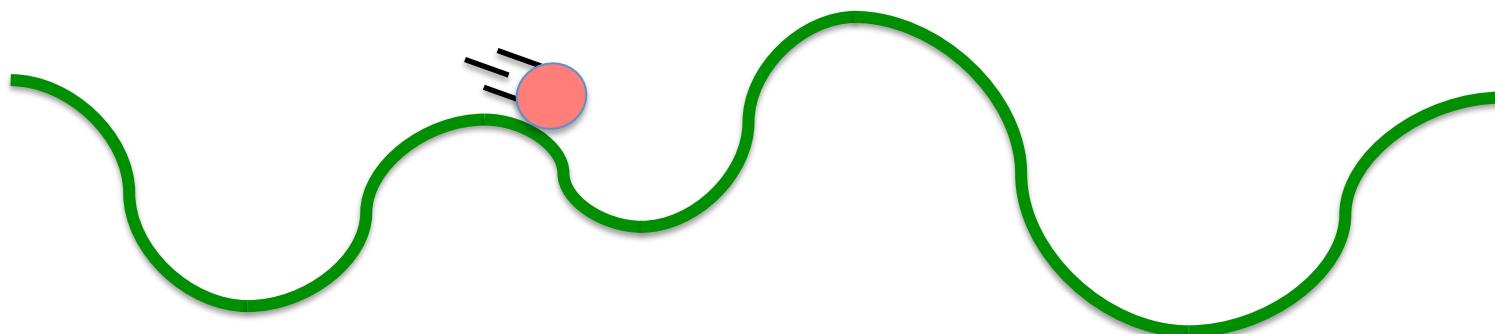
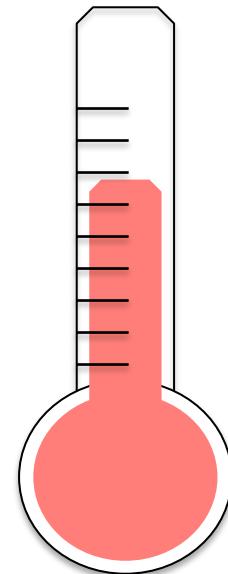
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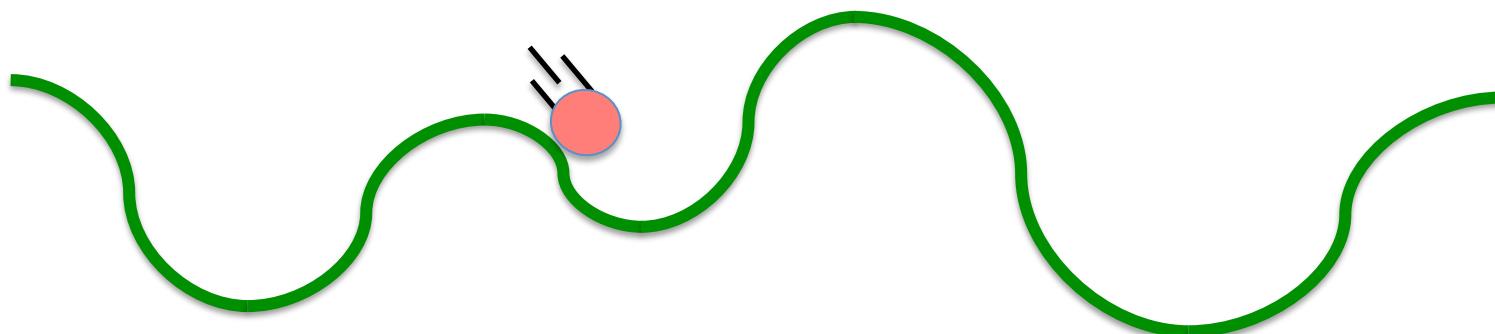
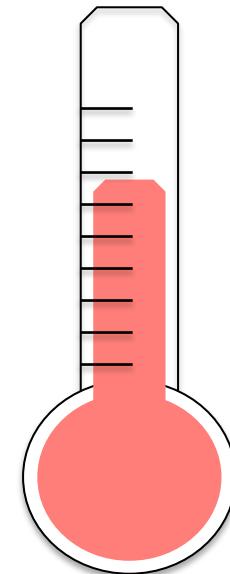
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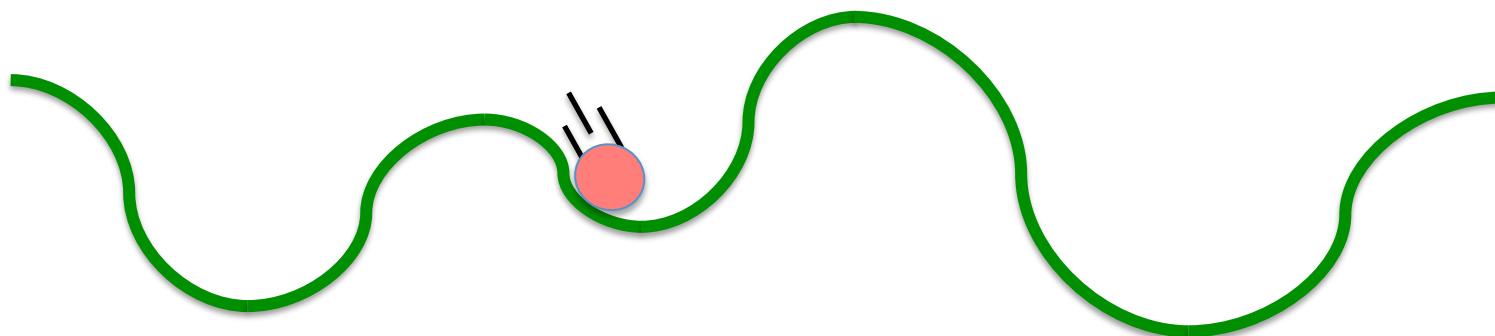
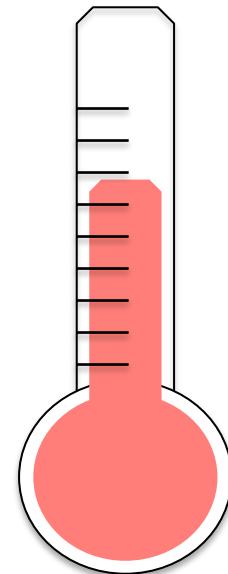
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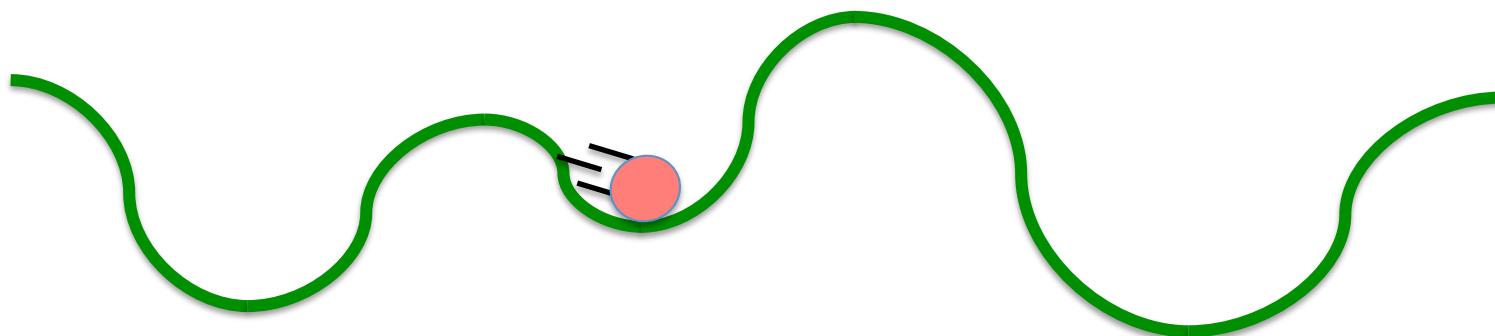
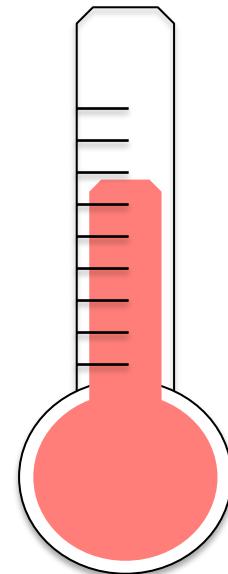
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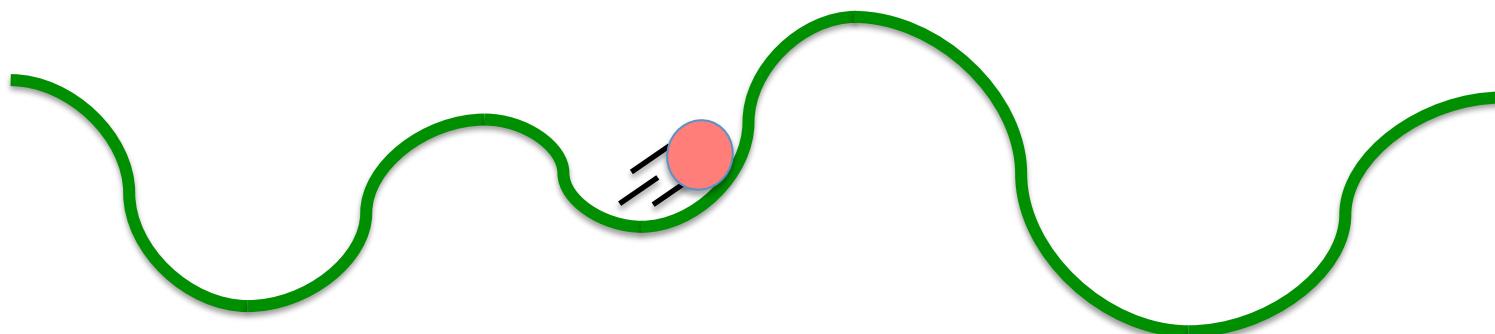
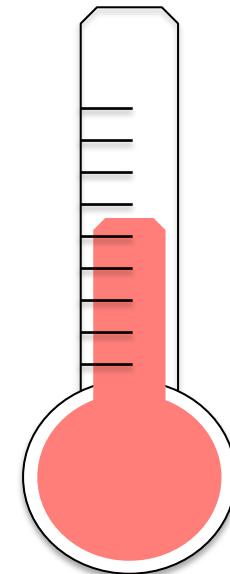
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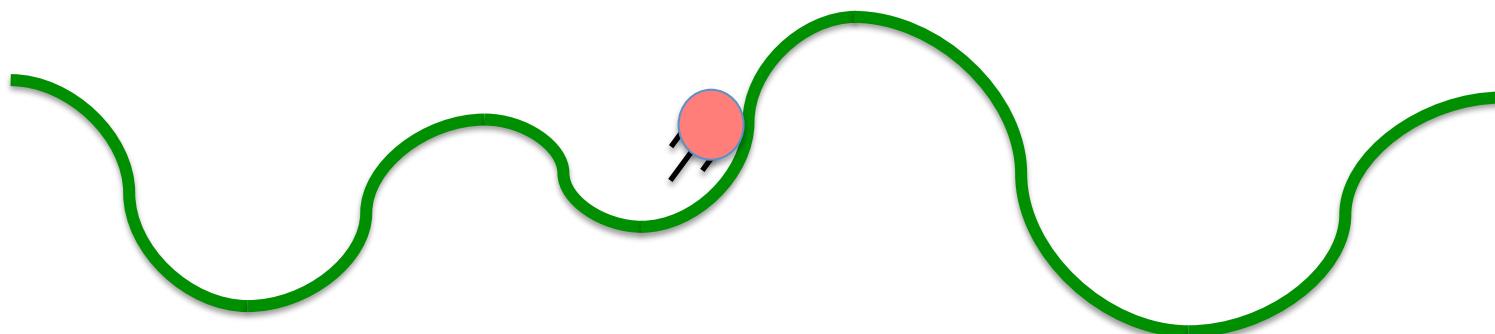
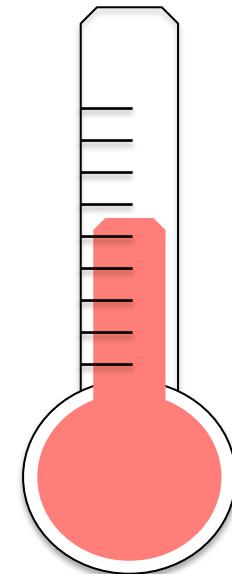
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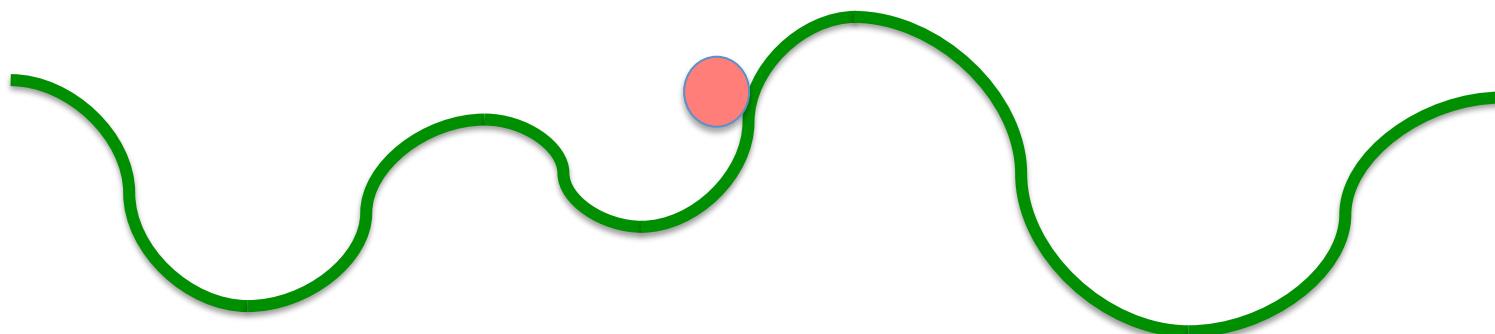
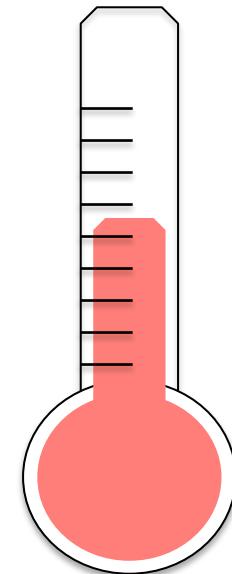
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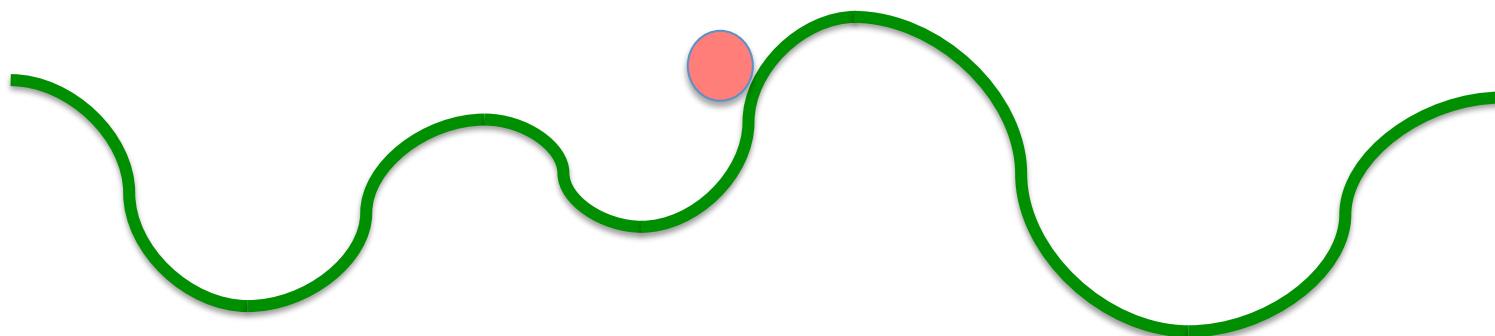
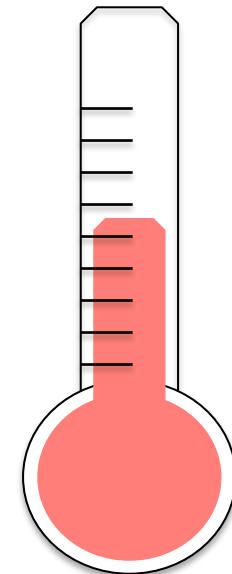
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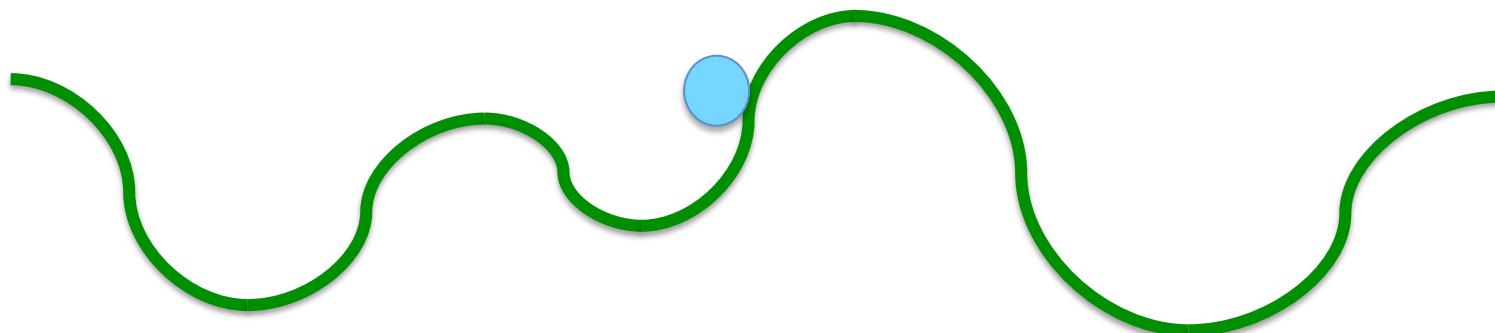
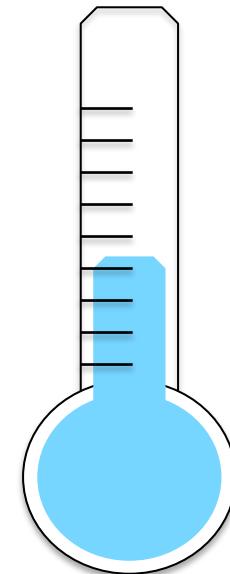
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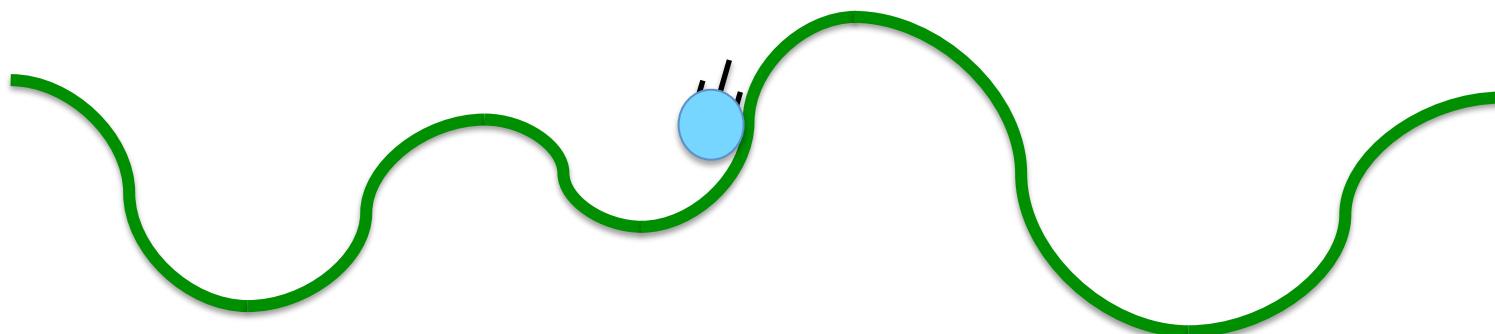
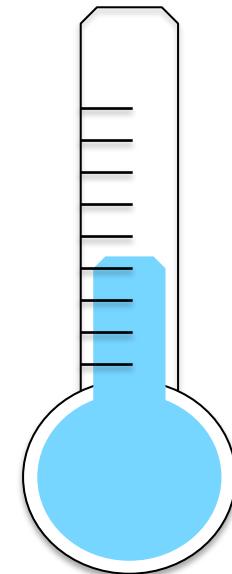
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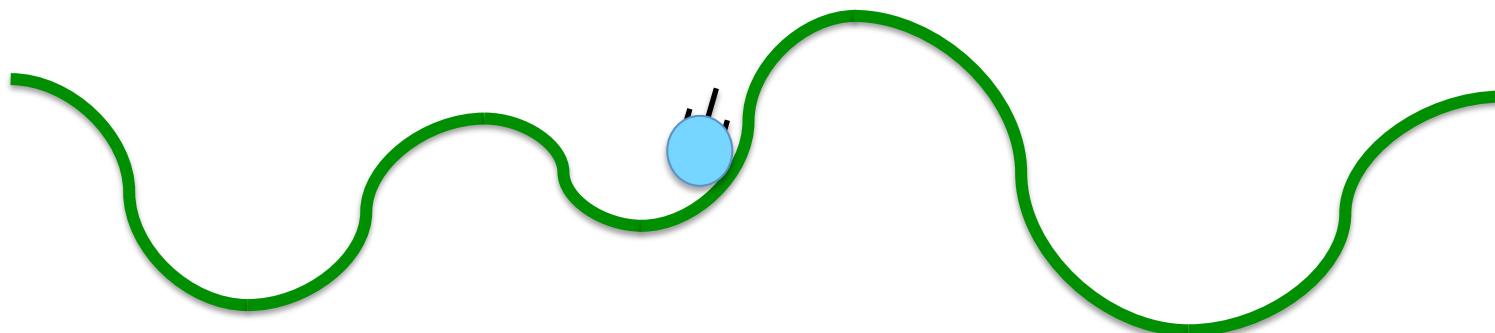
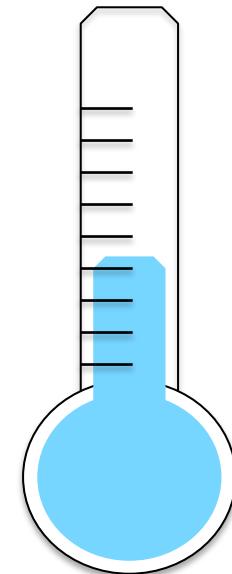
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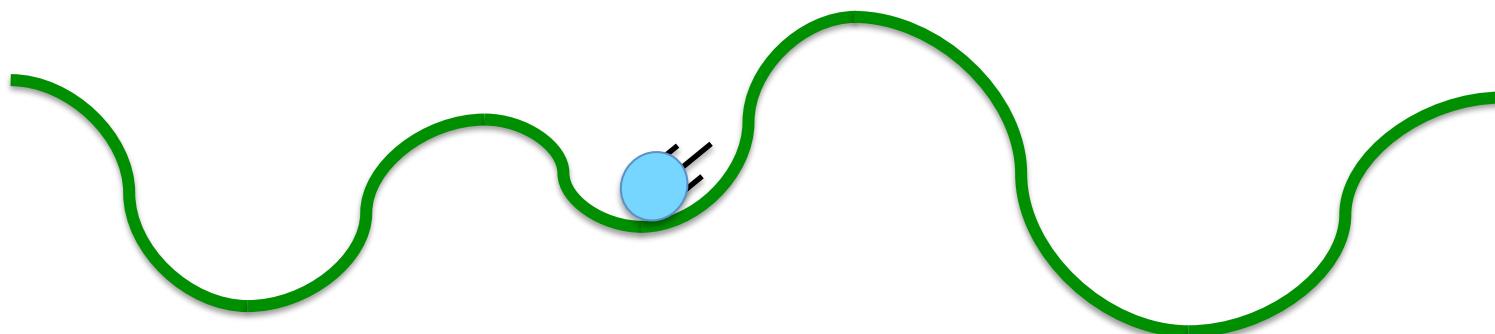
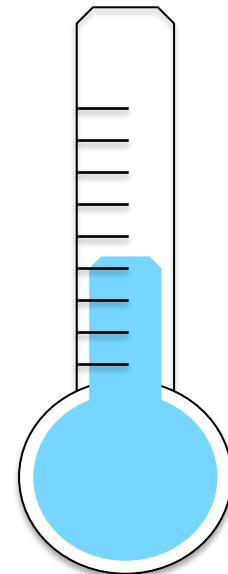
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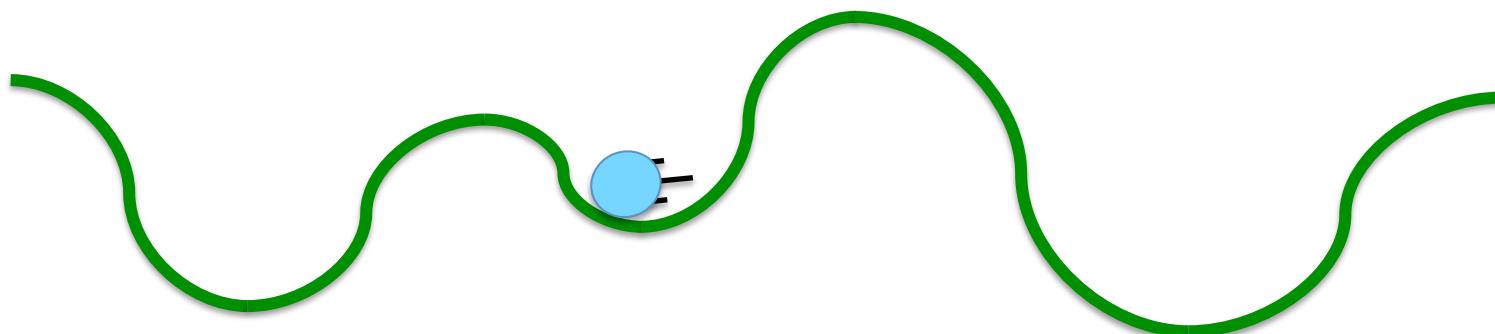
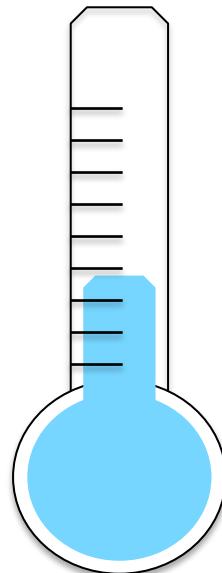
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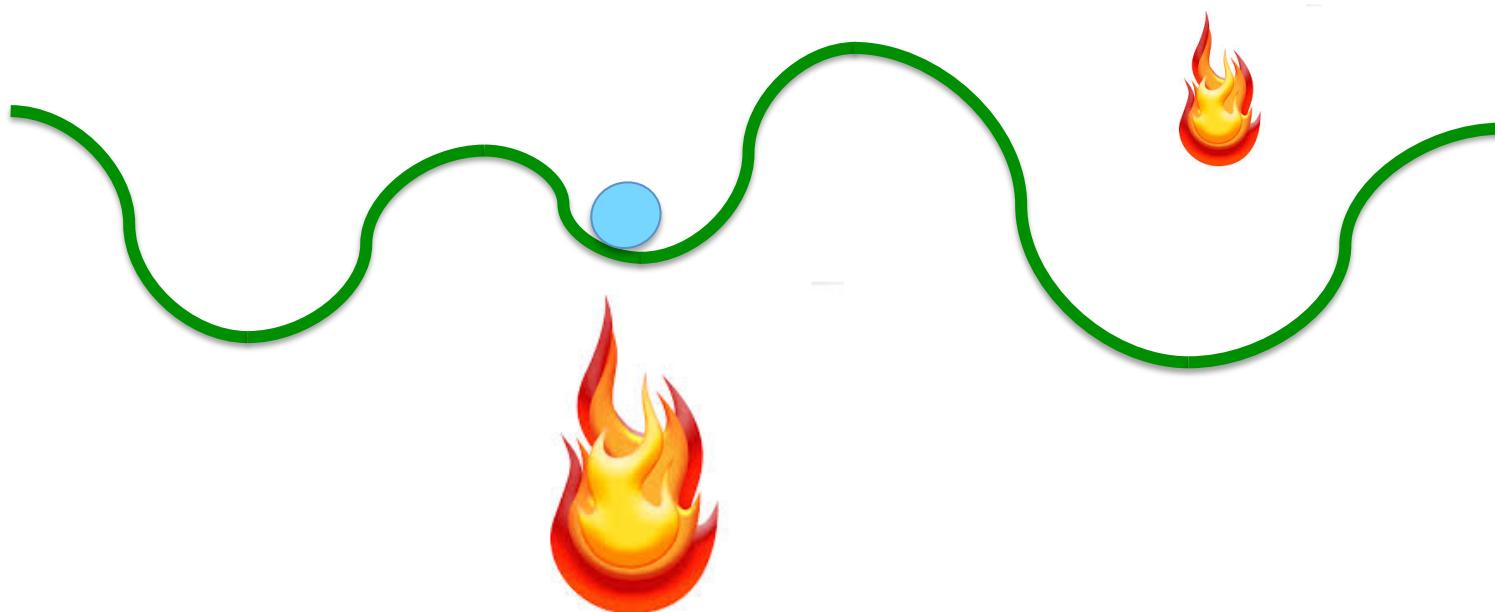
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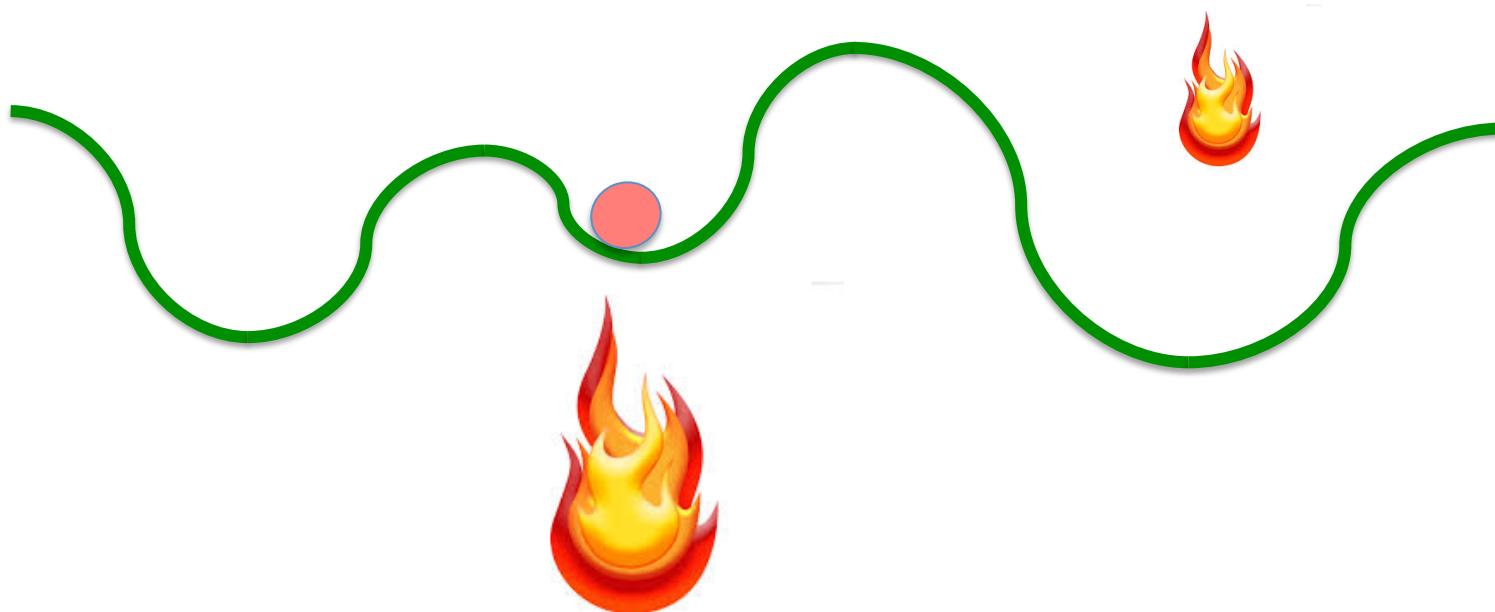
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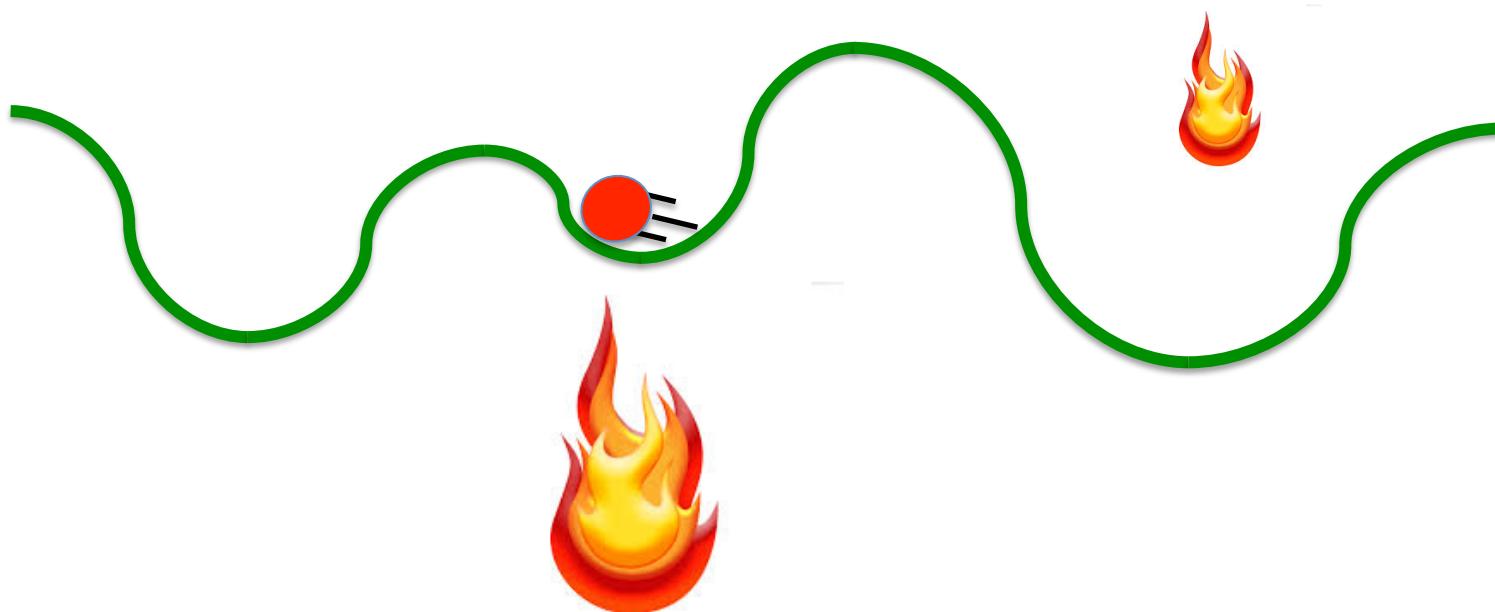
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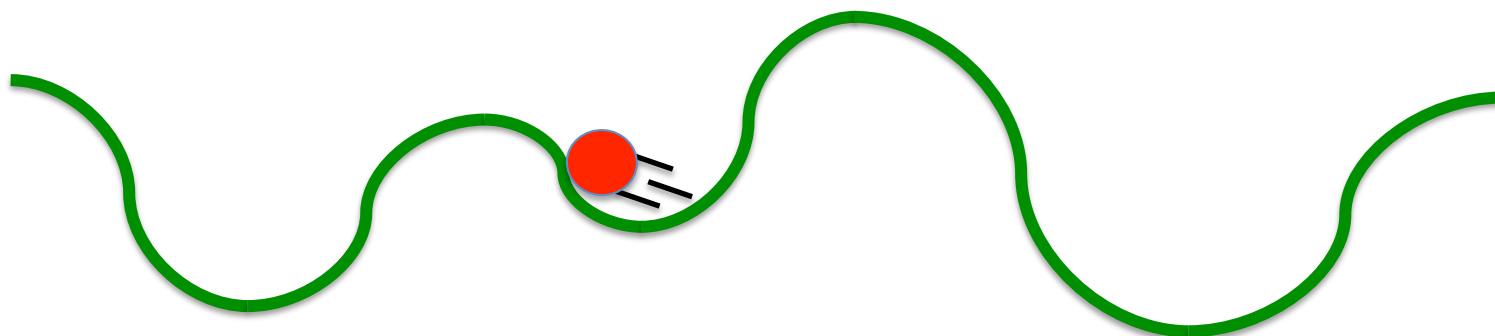
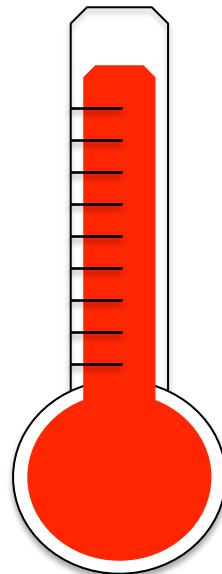
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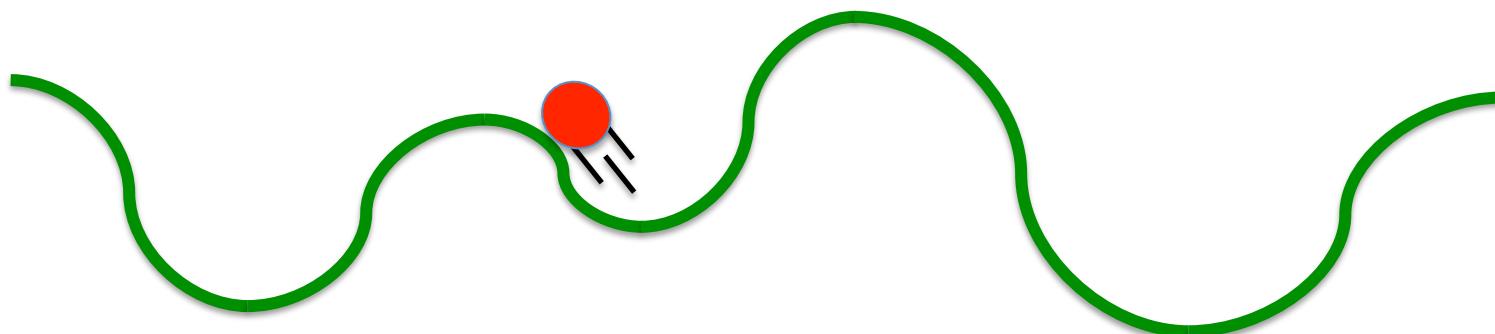
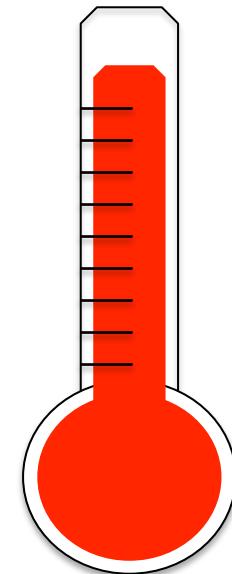
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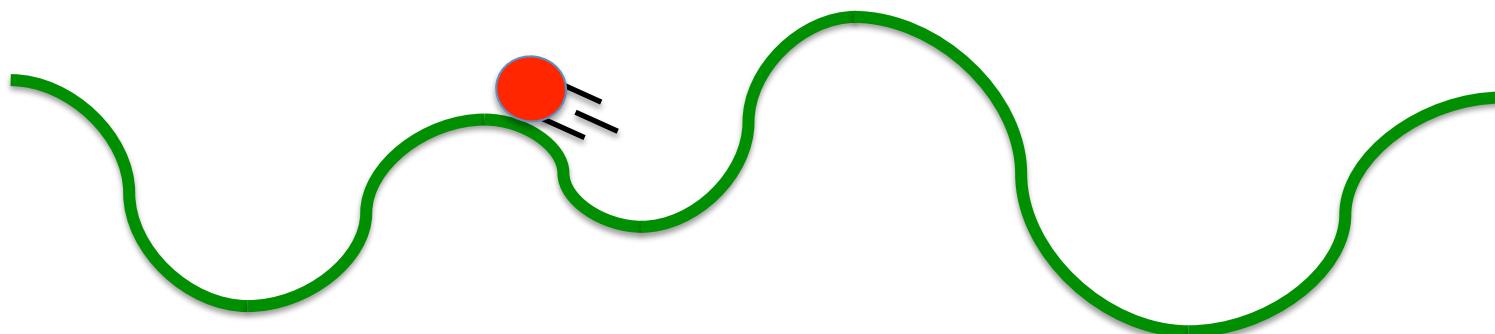
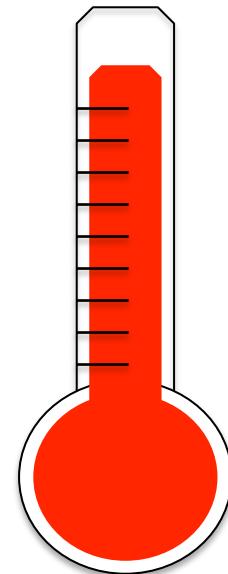
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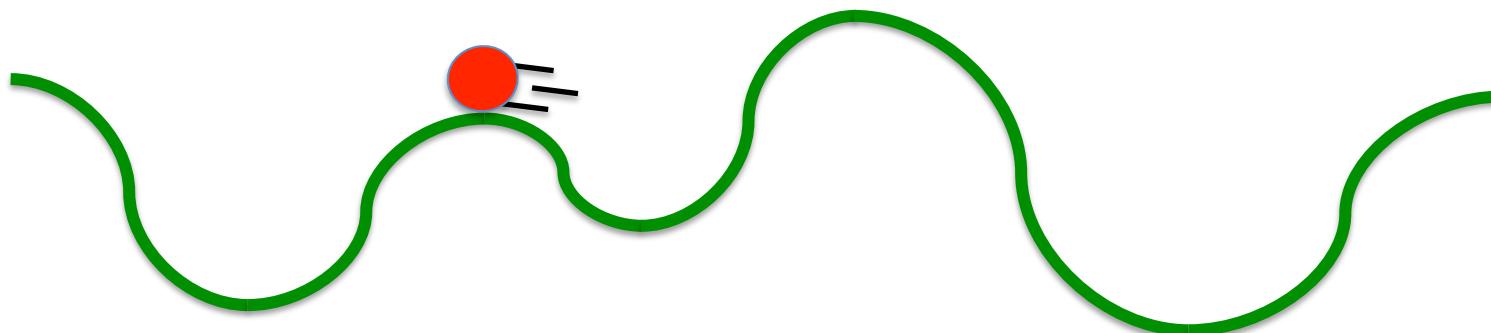
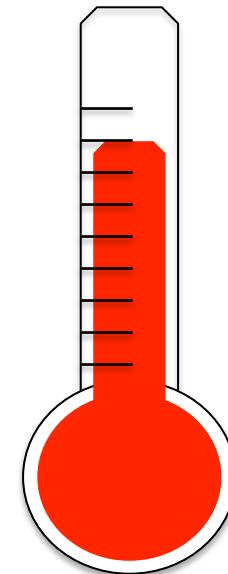
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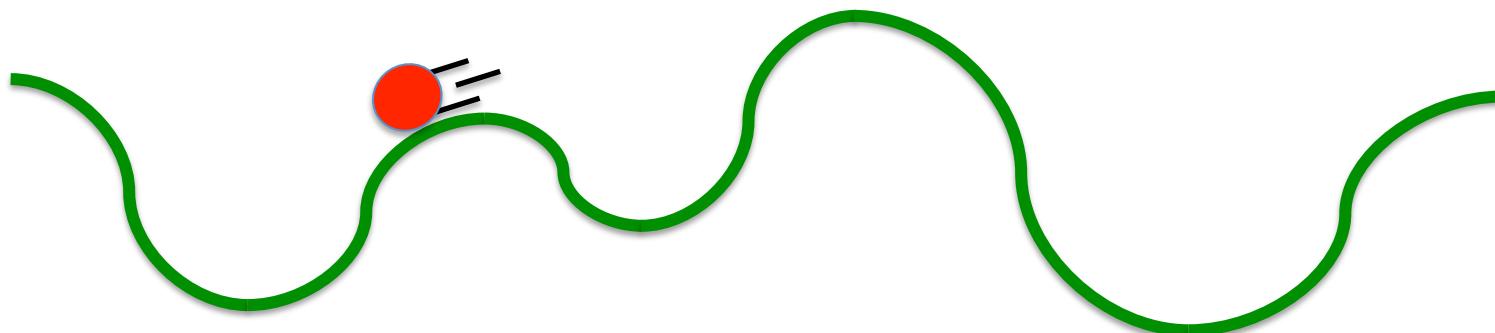
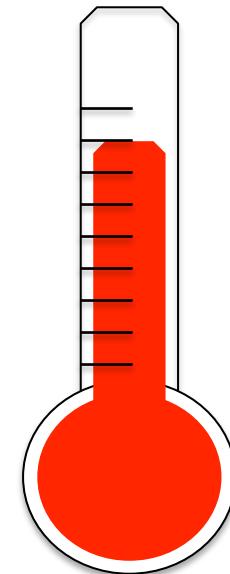
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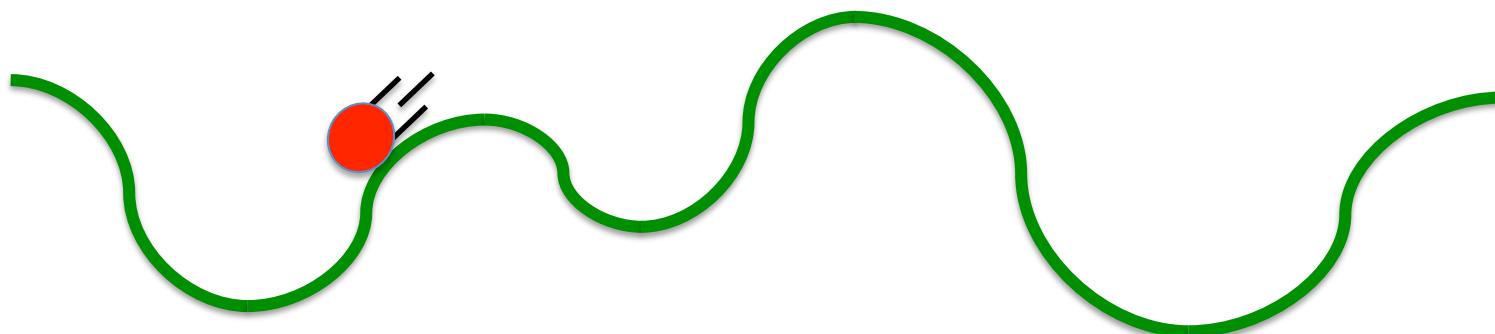
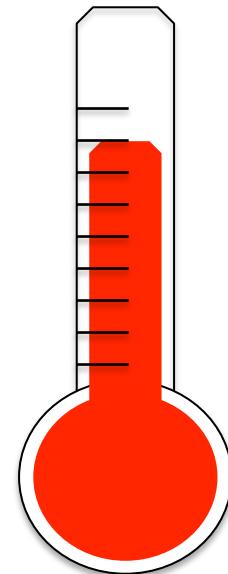
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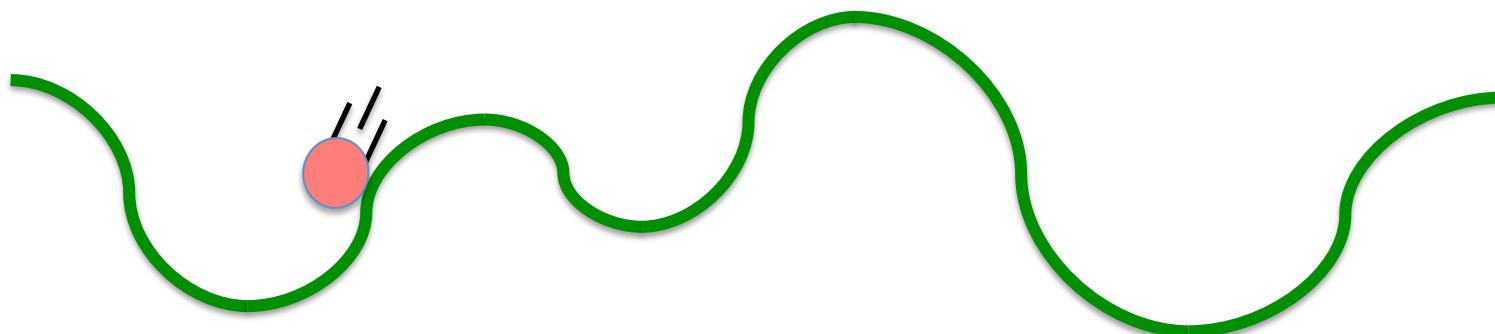
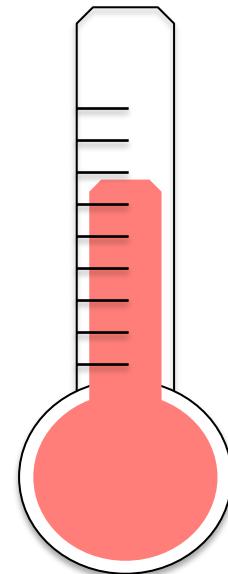
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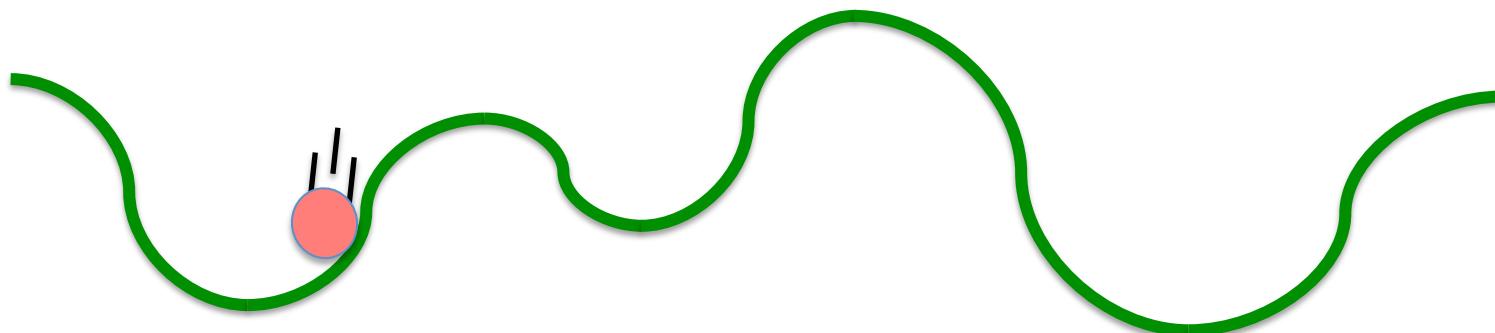
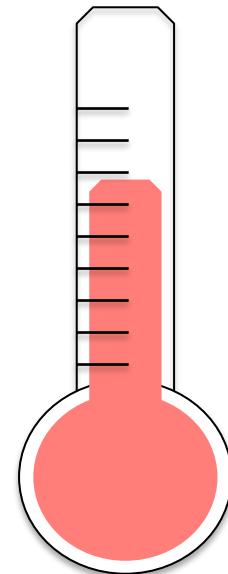
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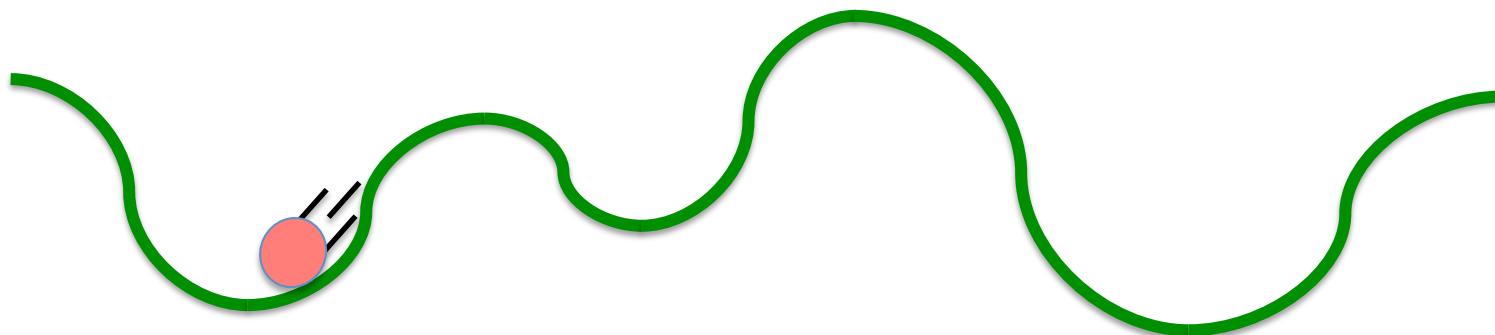
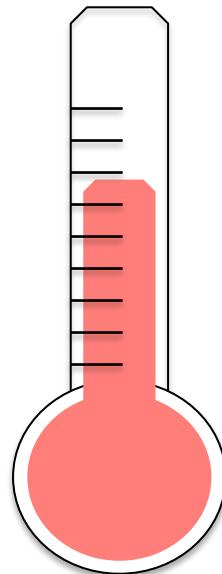
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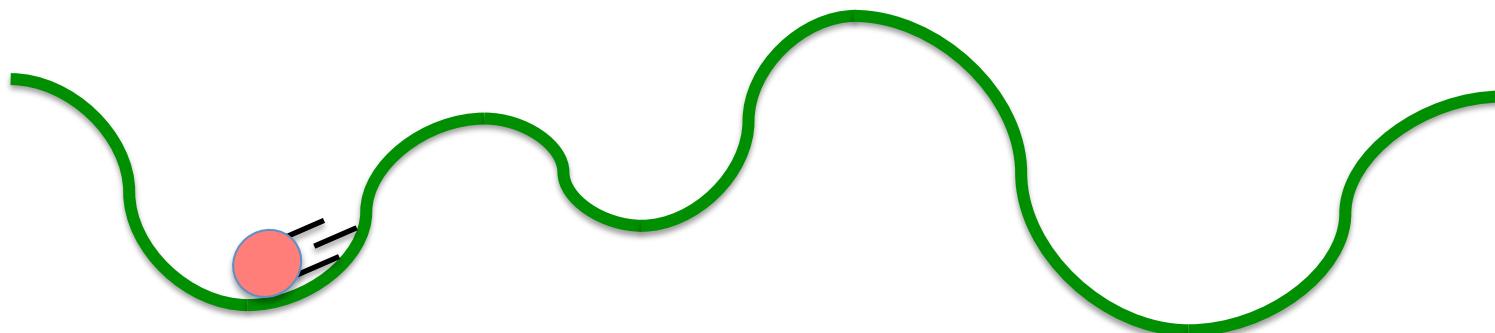
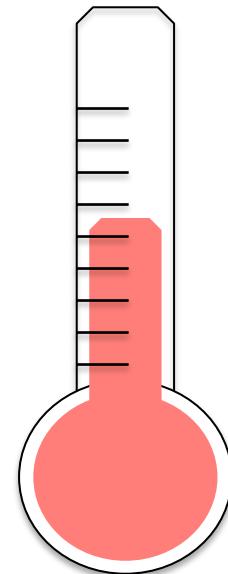
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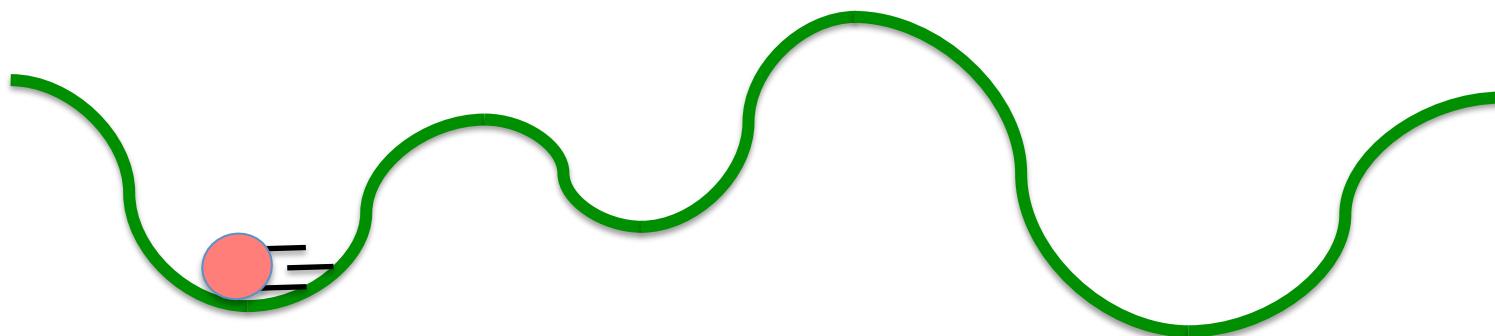
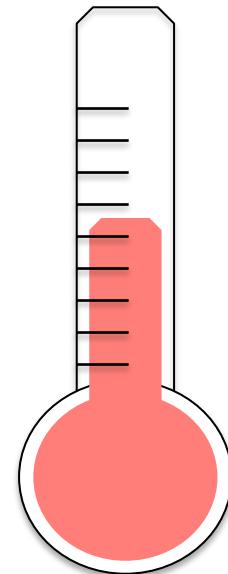
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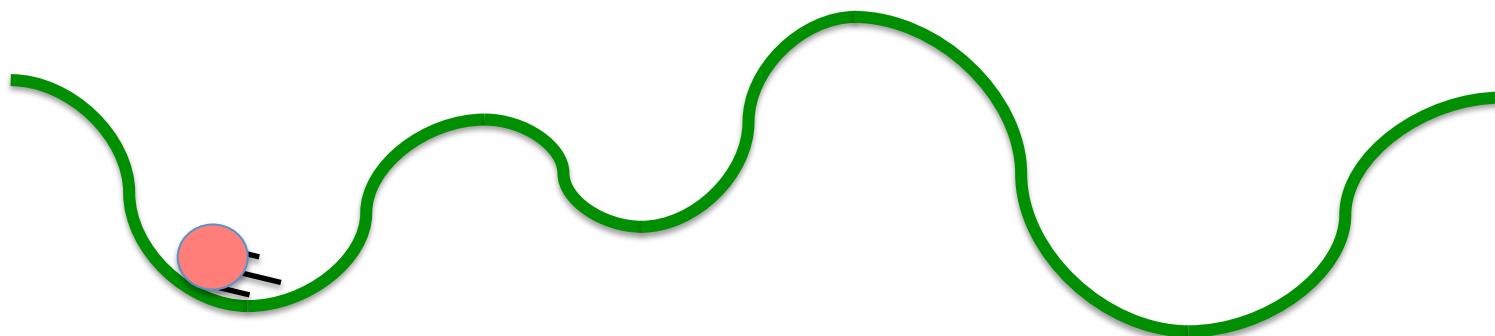
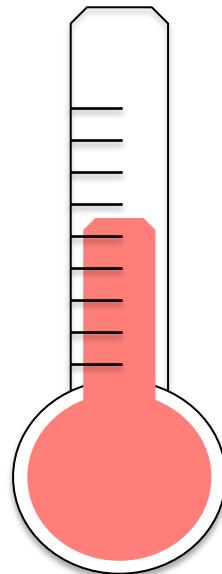
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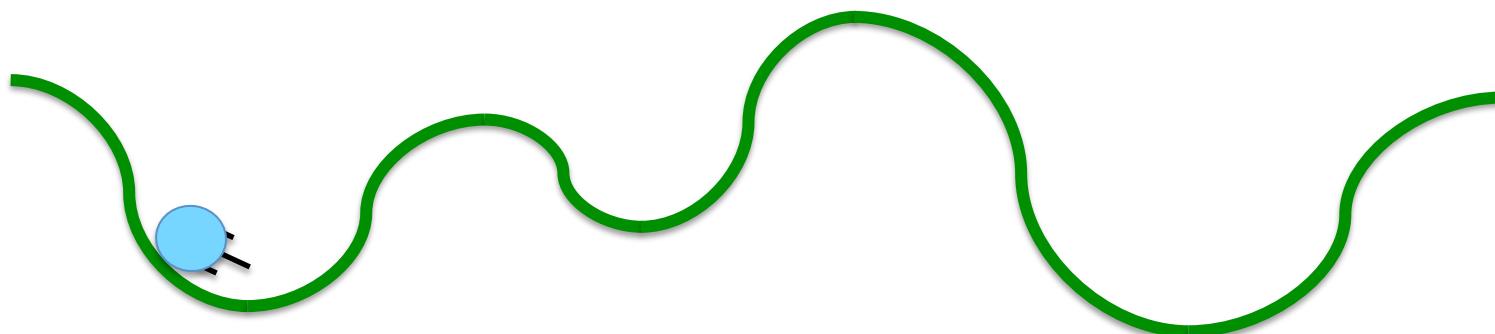
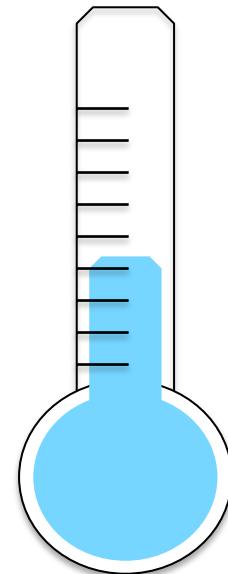
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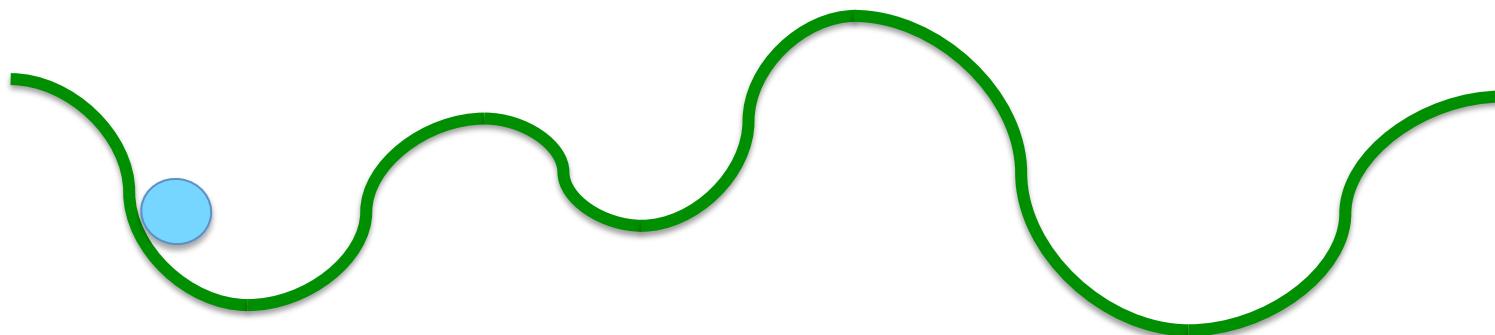
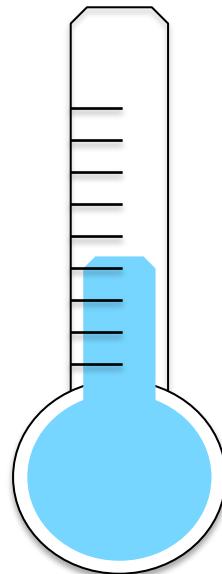
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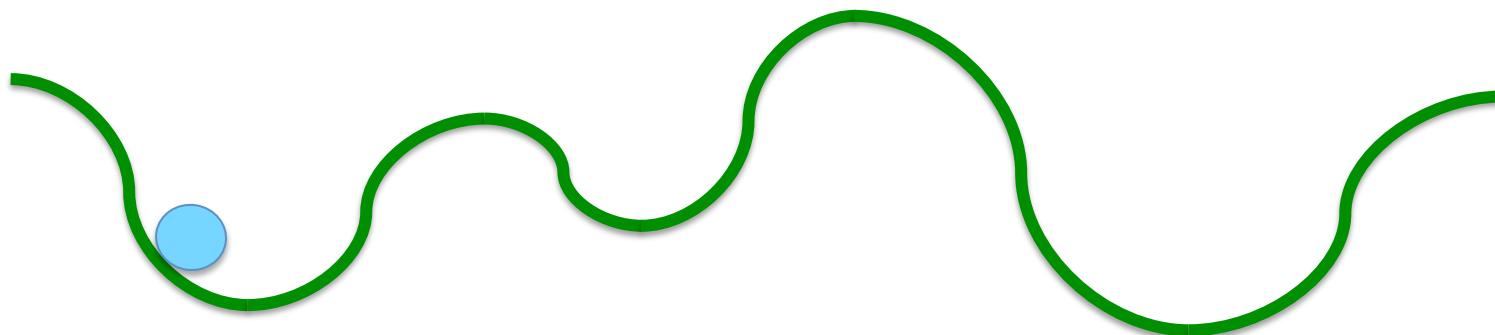
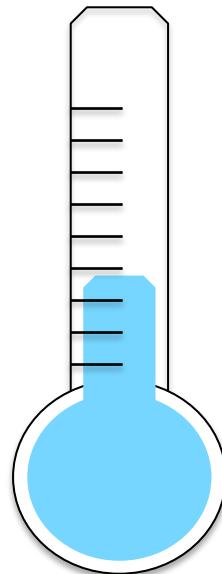
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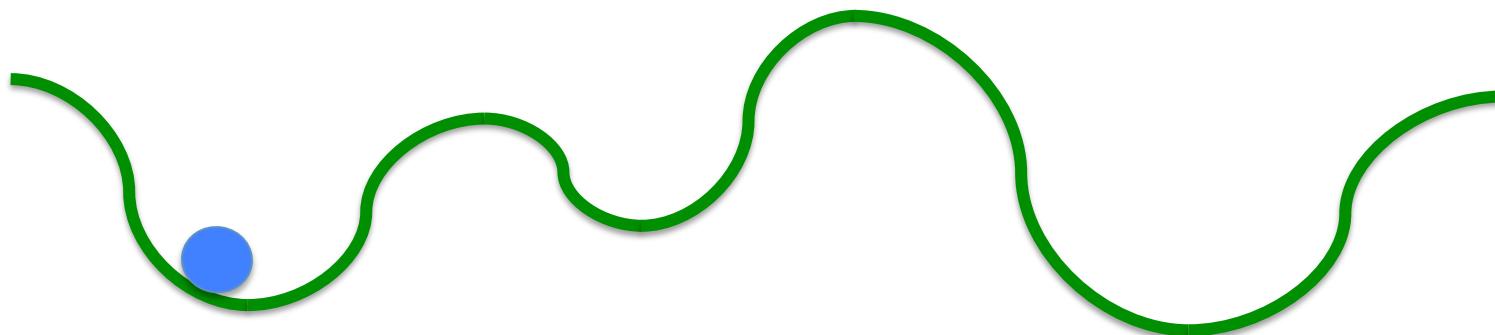
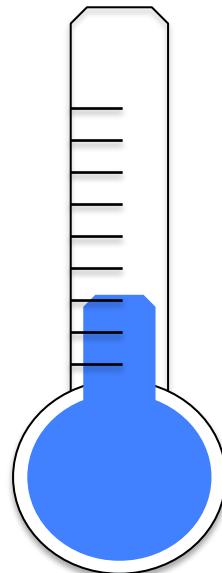
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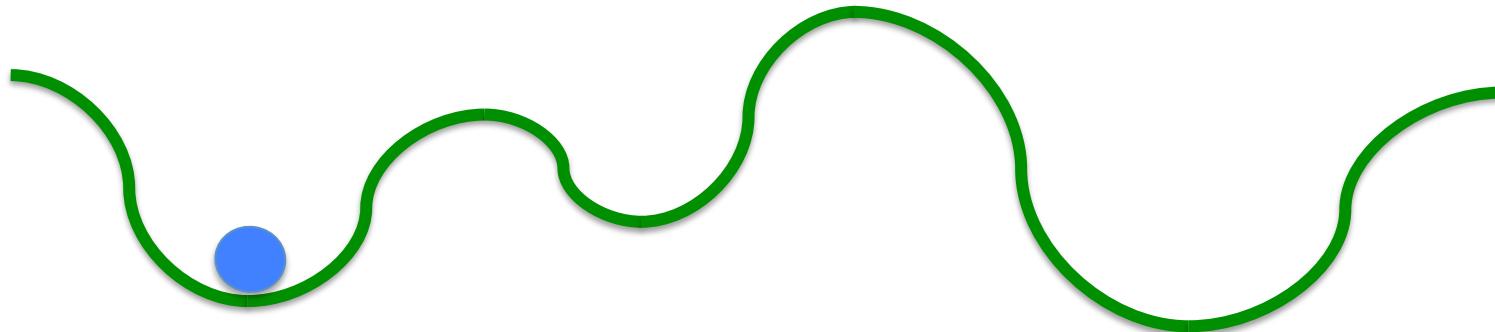
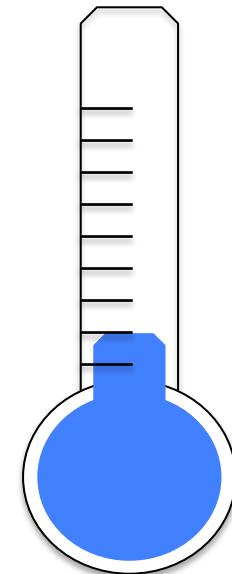
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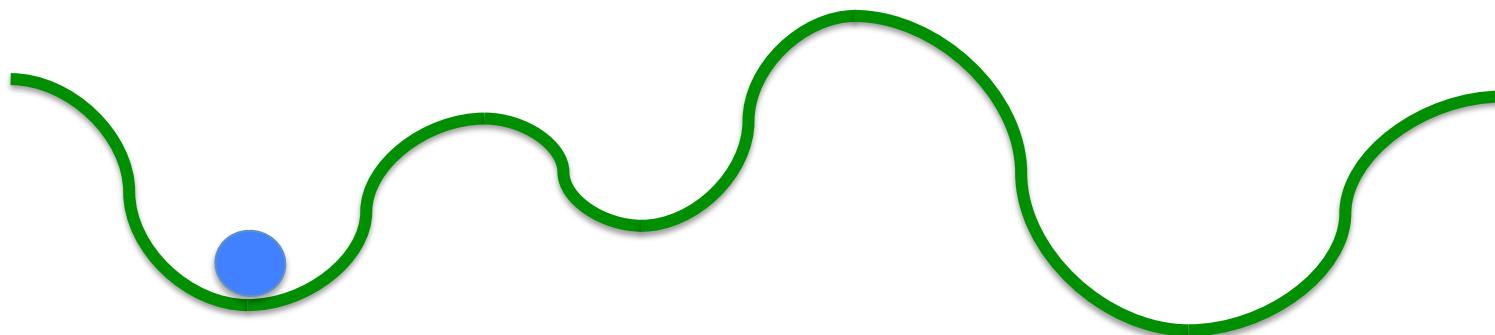
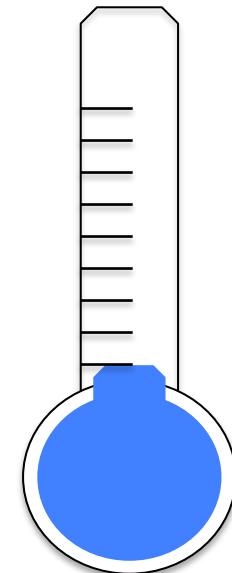
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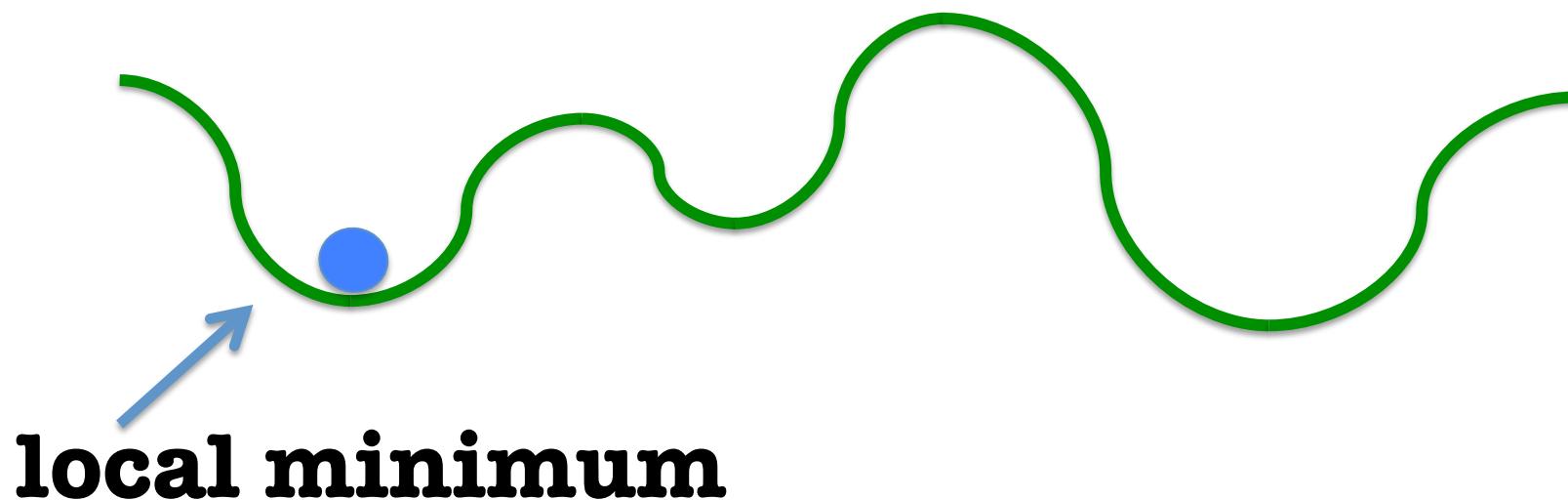
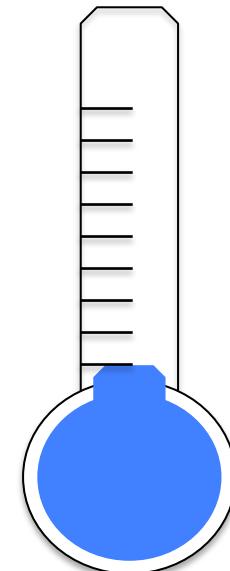
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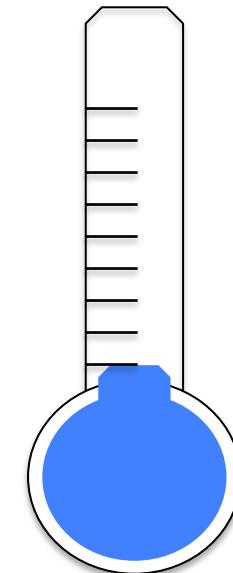
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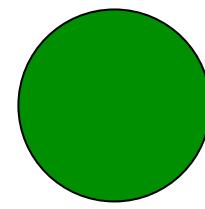
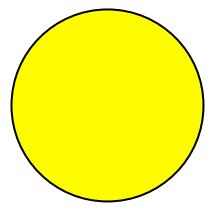
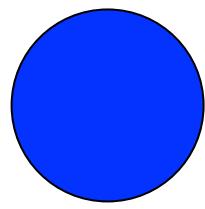
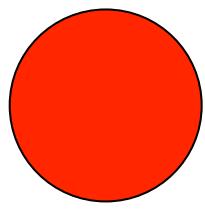


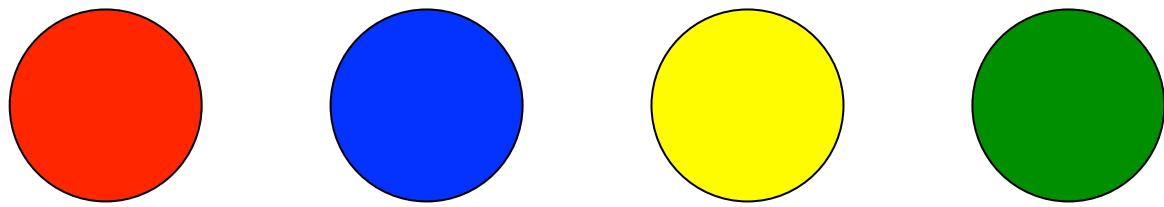
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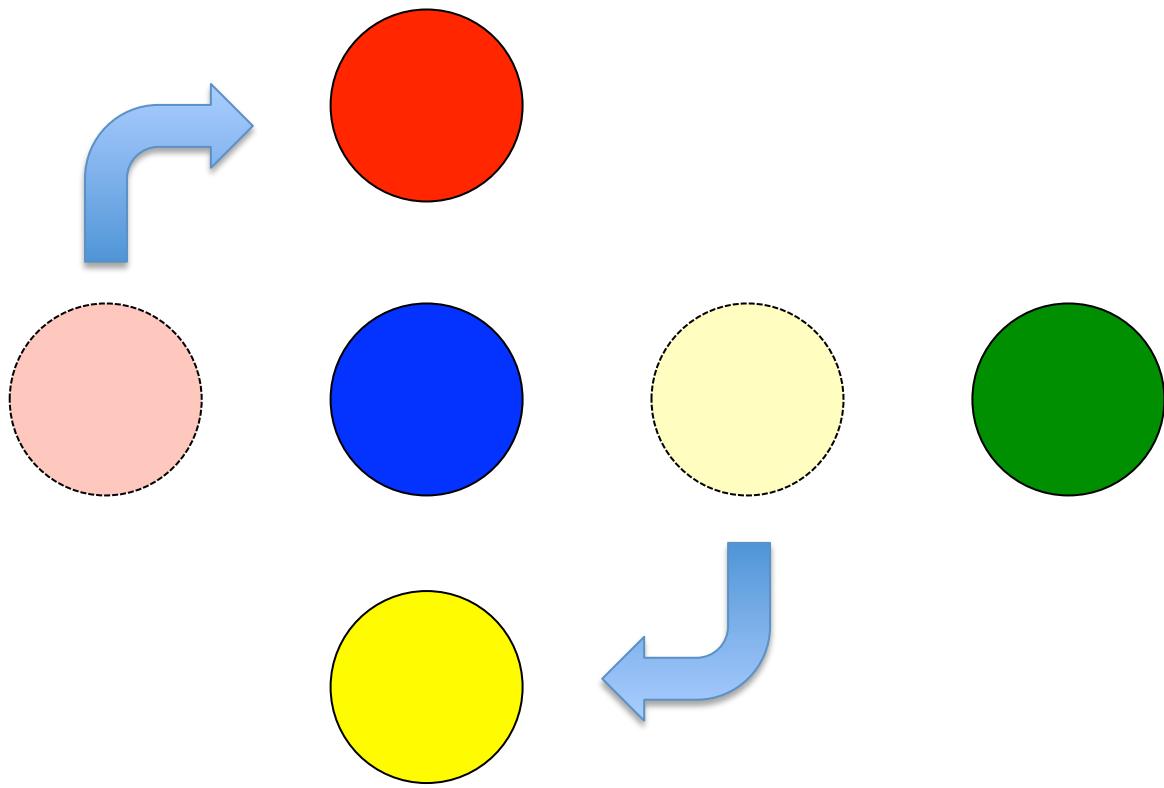
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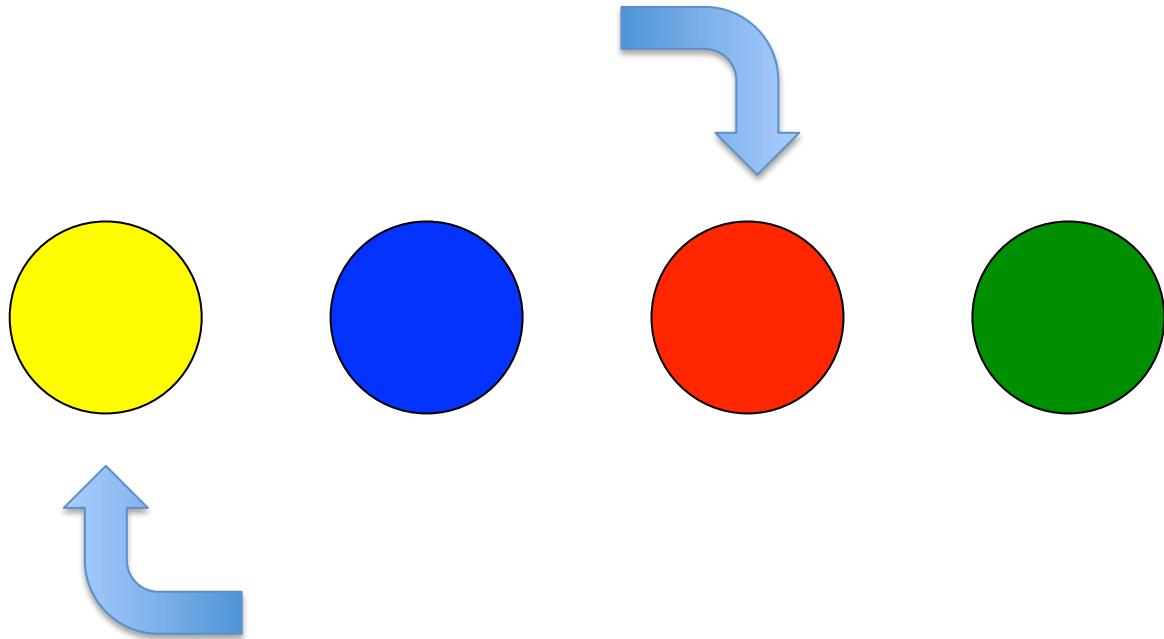




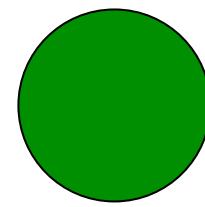
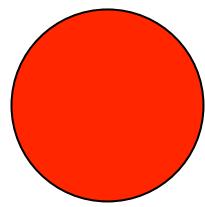
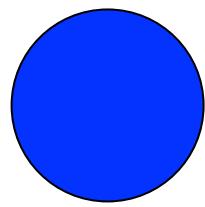
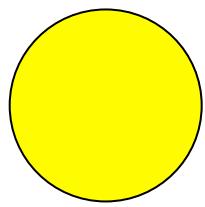
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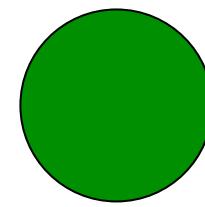
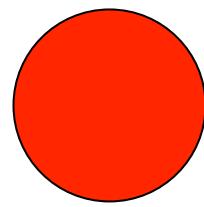
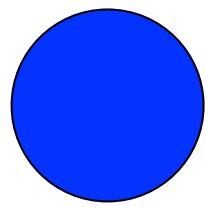
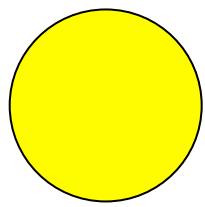


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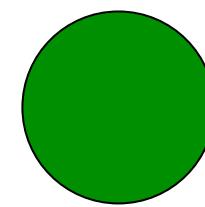
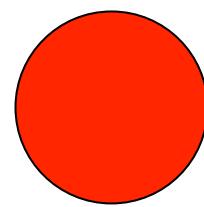
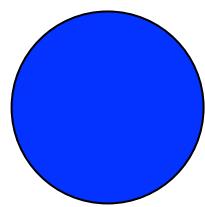
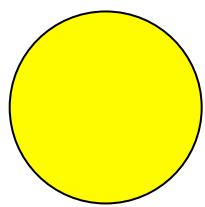


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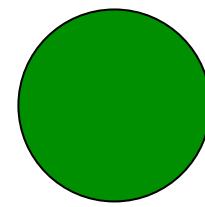
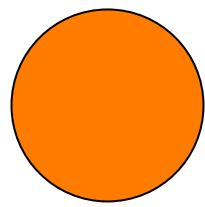
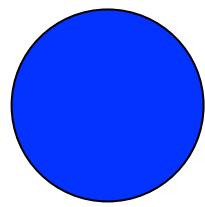
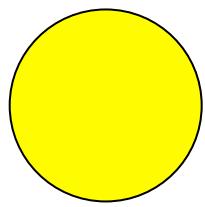




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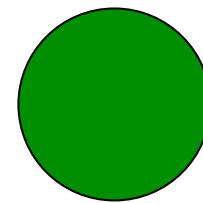
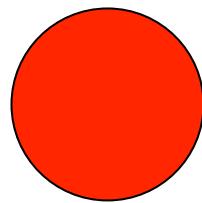
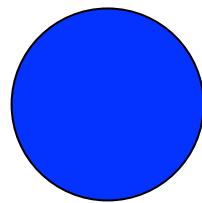
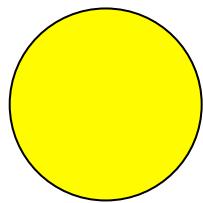
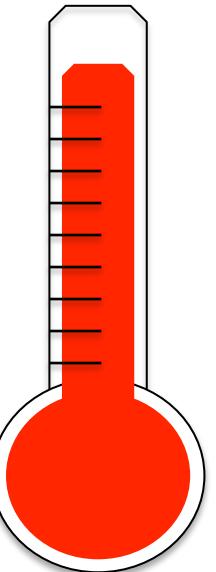
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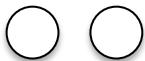
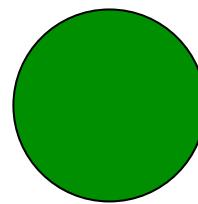
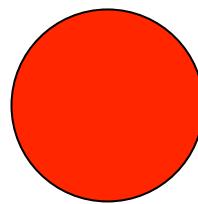
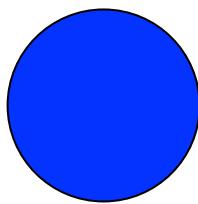
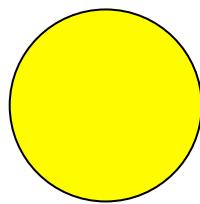
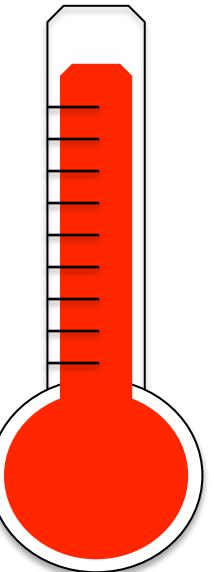
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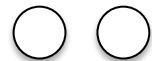
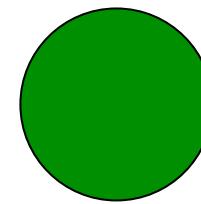
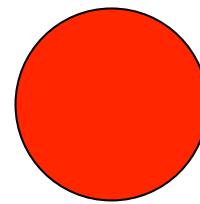
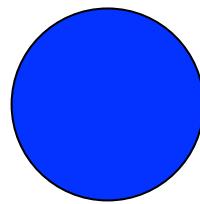
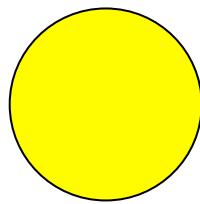
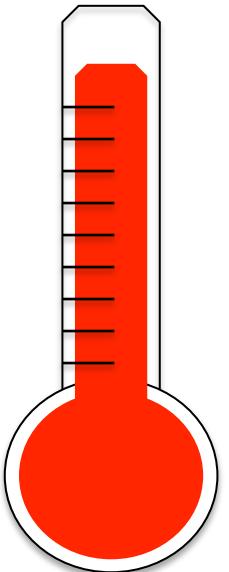
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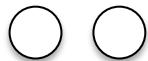
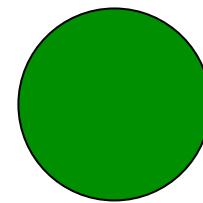
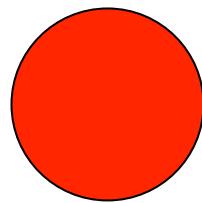
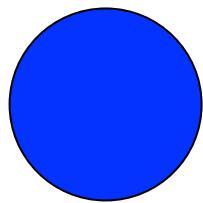
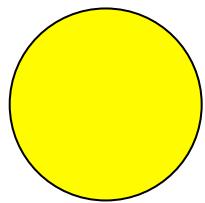
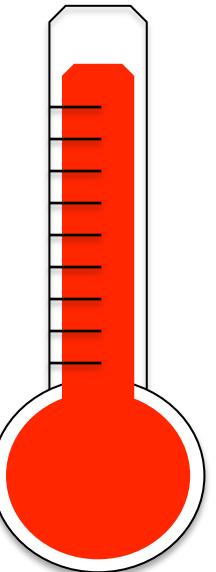
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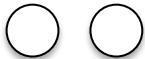
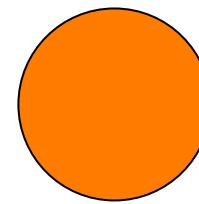
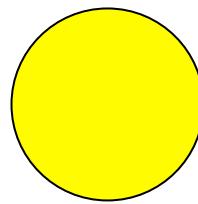
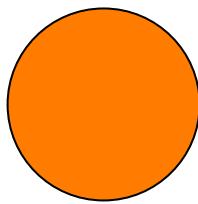
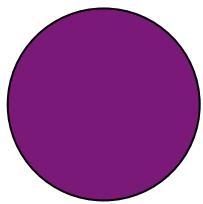
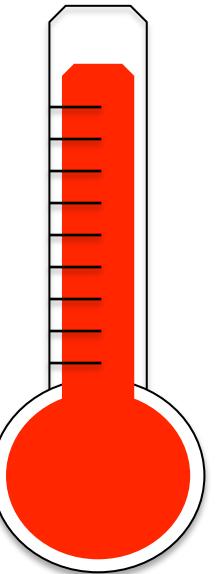
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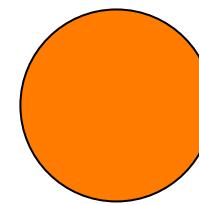
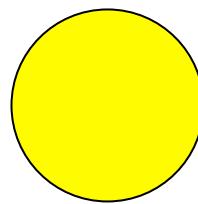
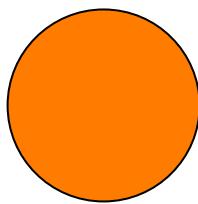
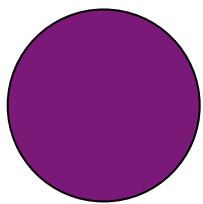
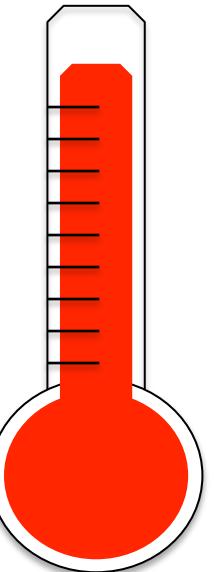
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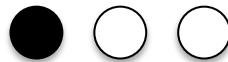
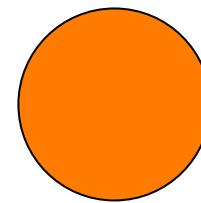
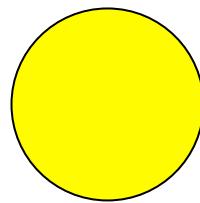
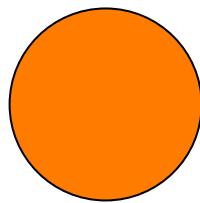
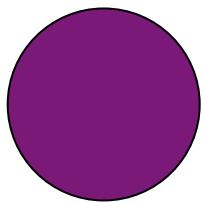
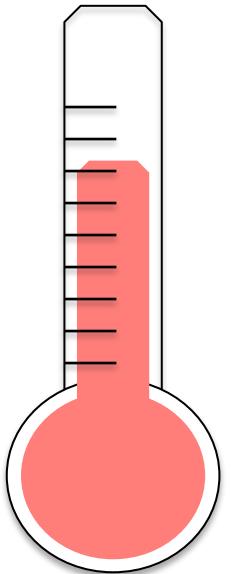
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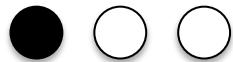
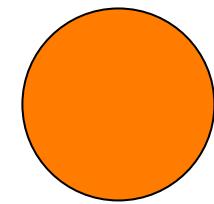
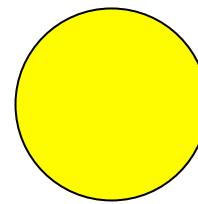
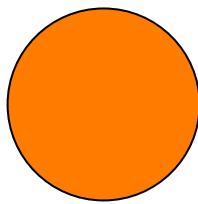
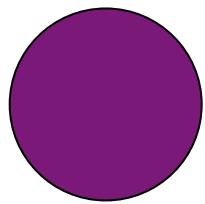
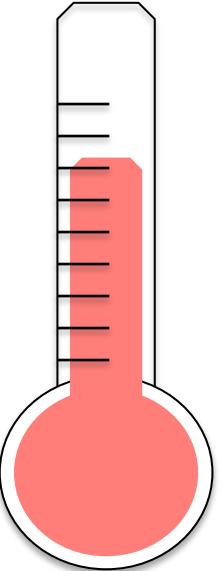
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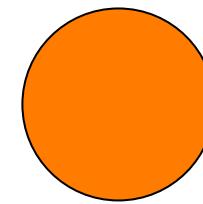
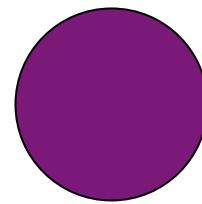
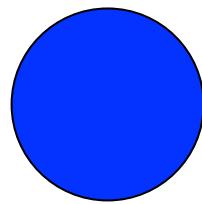
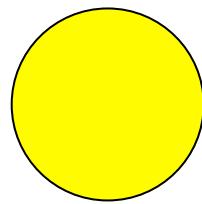
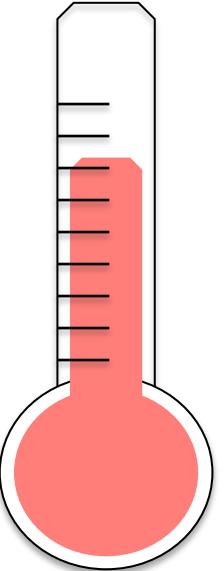
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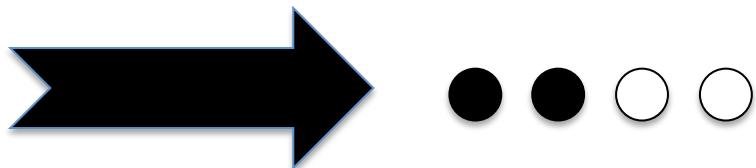
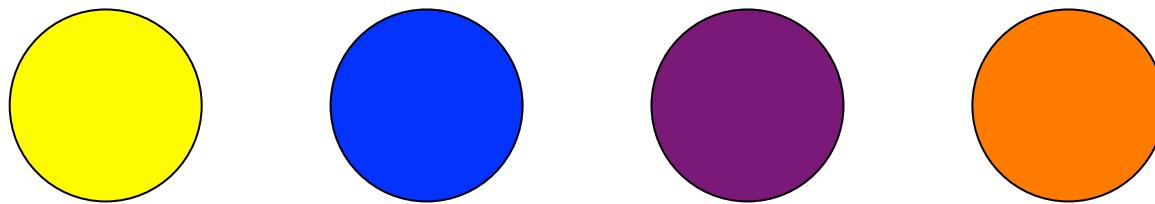
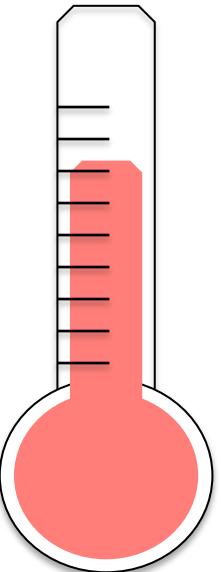
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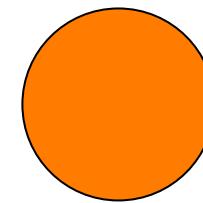
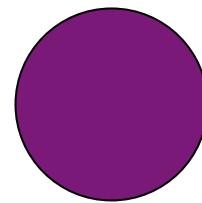
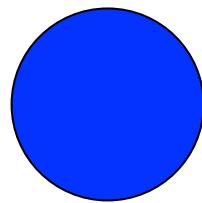
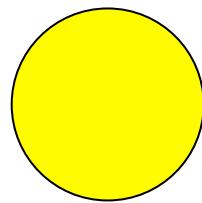
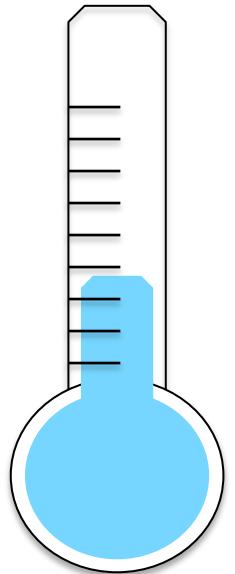
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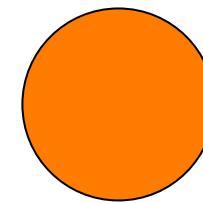
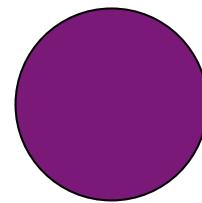
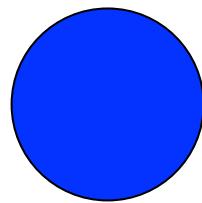
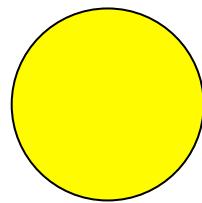
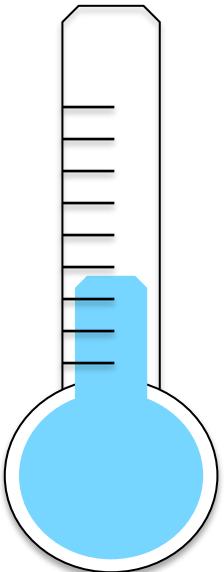
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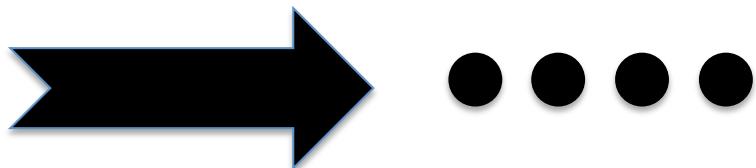
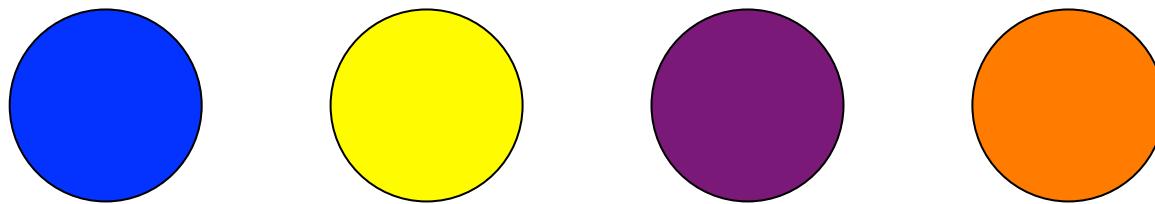
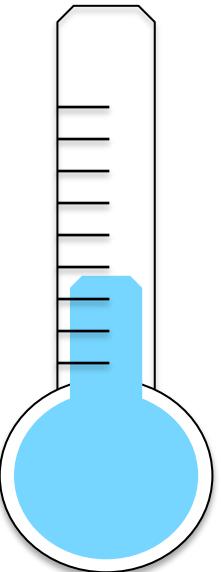
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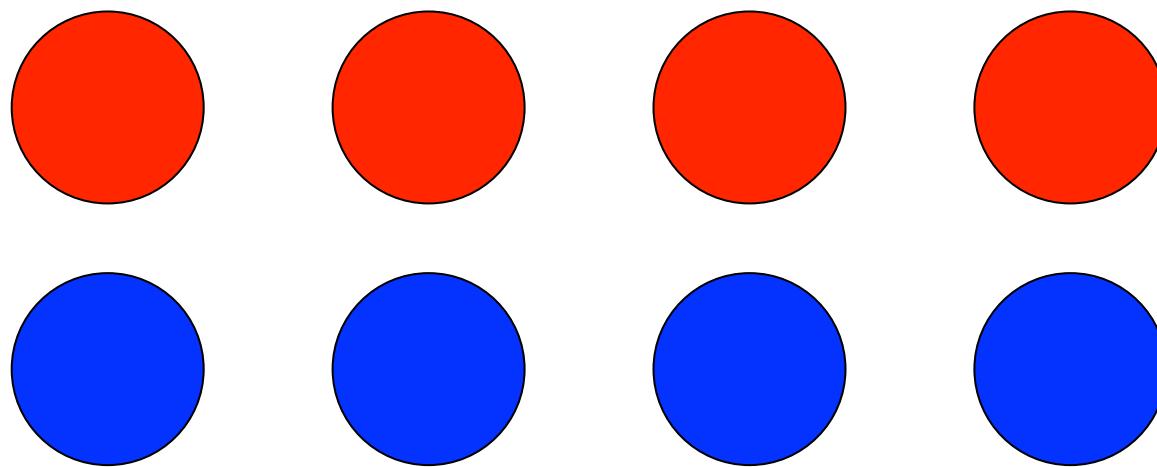


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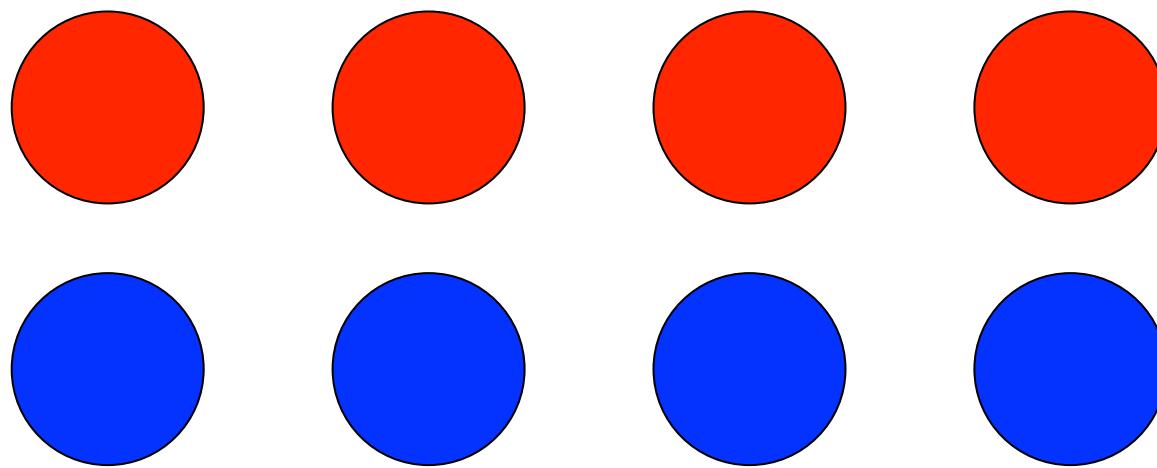


GENETIC ALGORITHMS

GENETIC ALGORITHMS

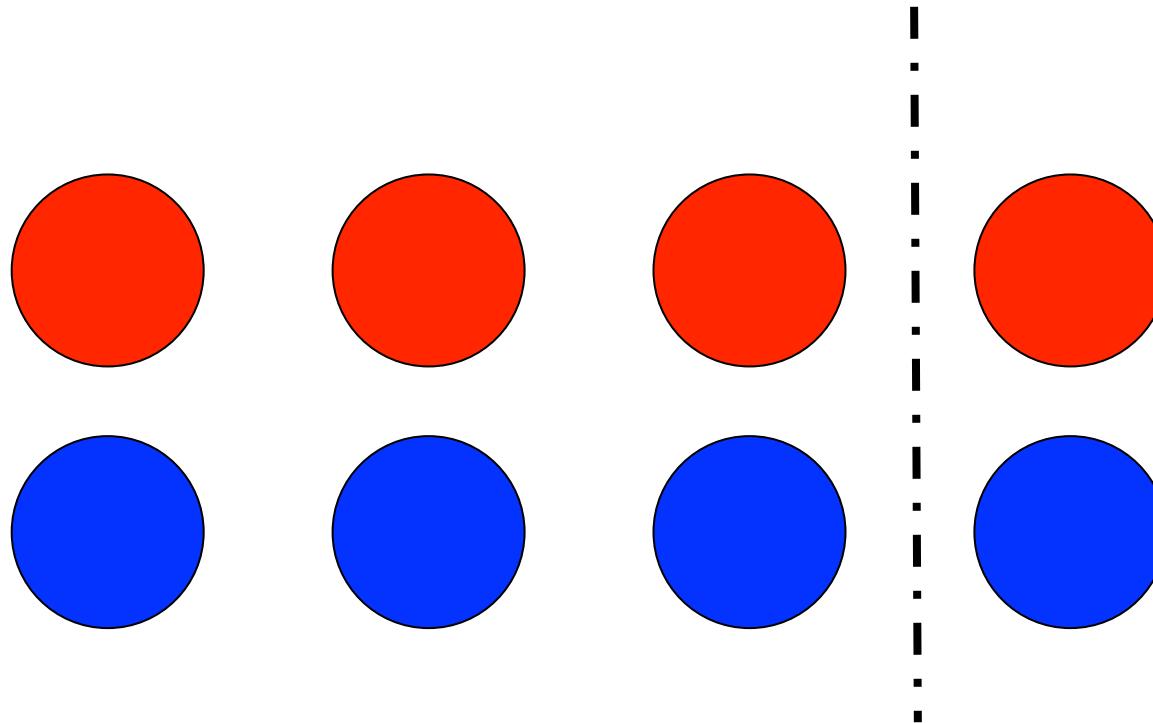


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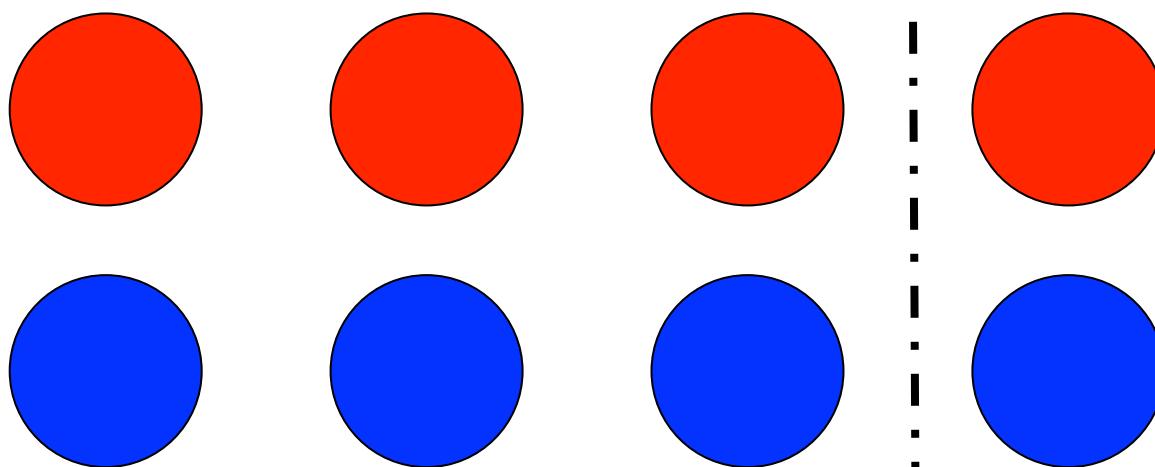
crossover

GENETIC ALGORITHMS



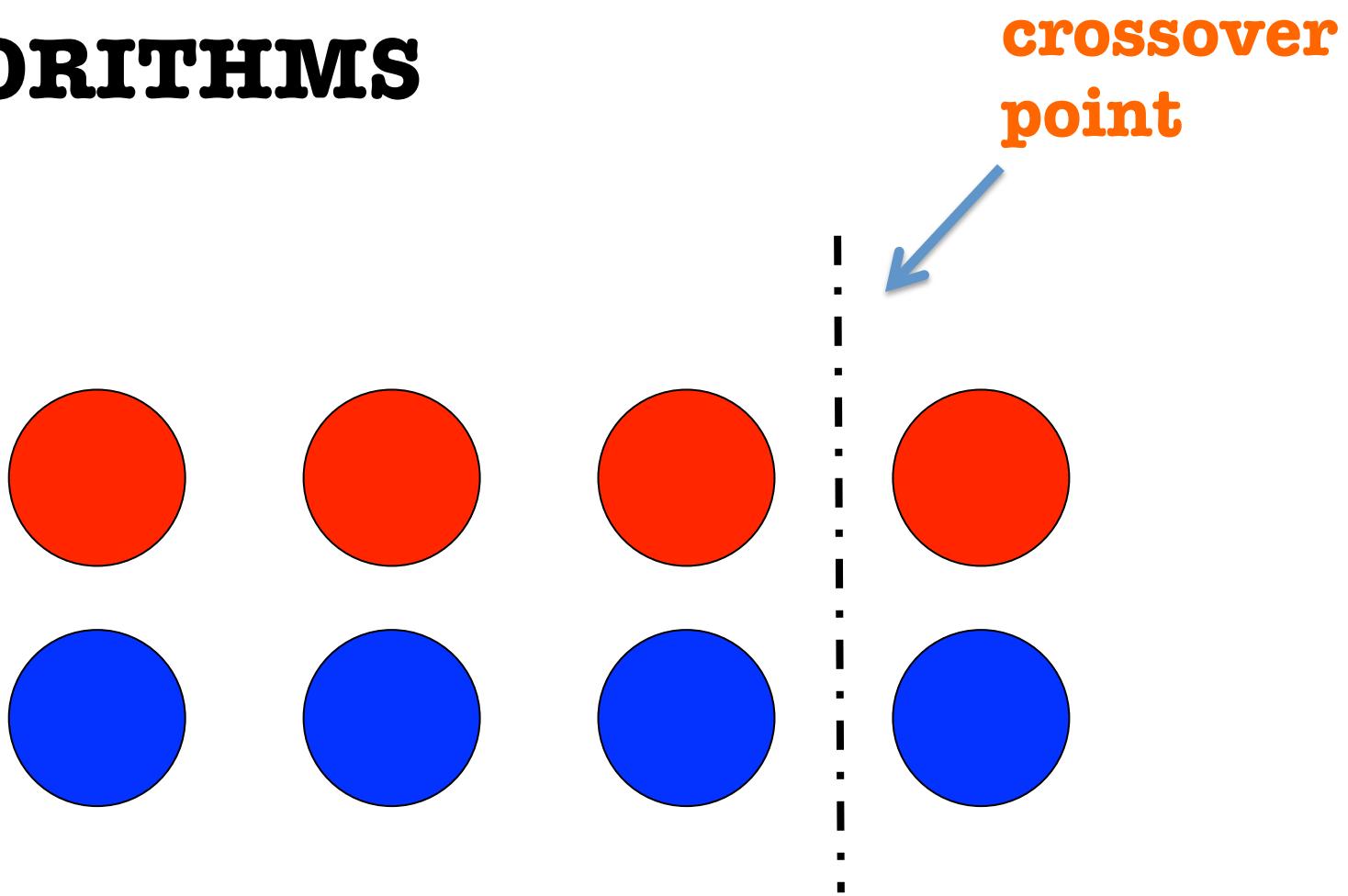
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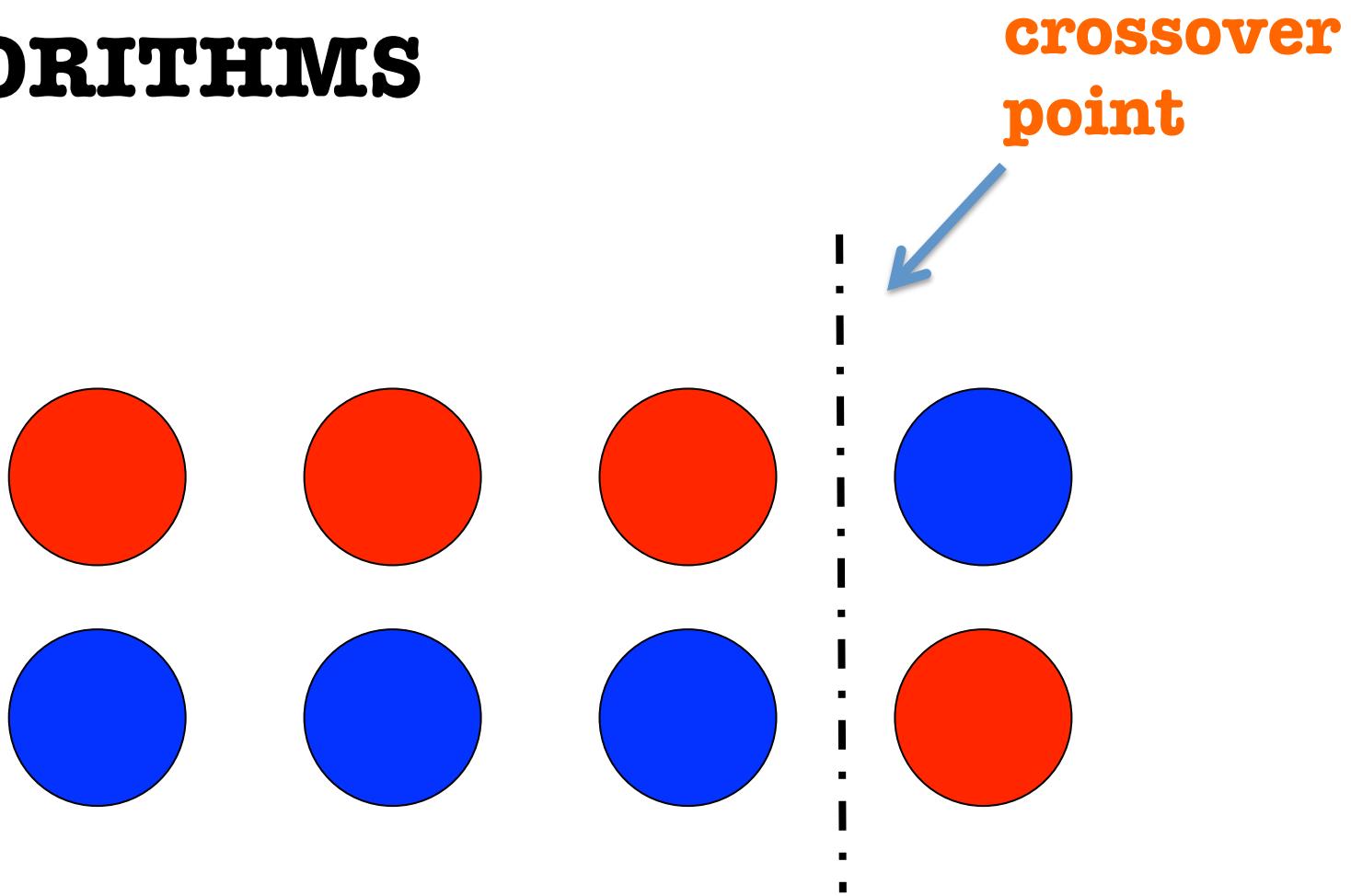
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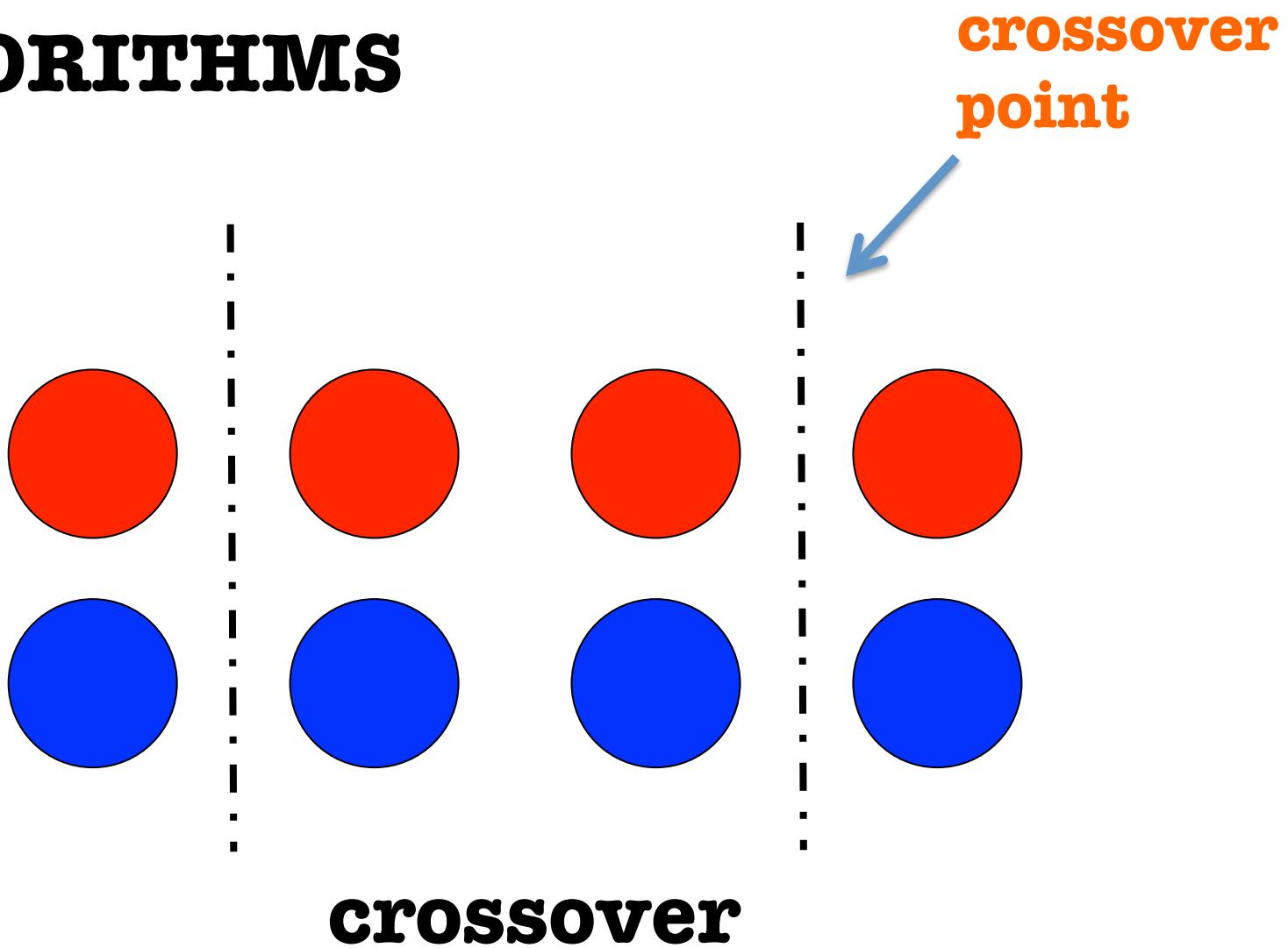
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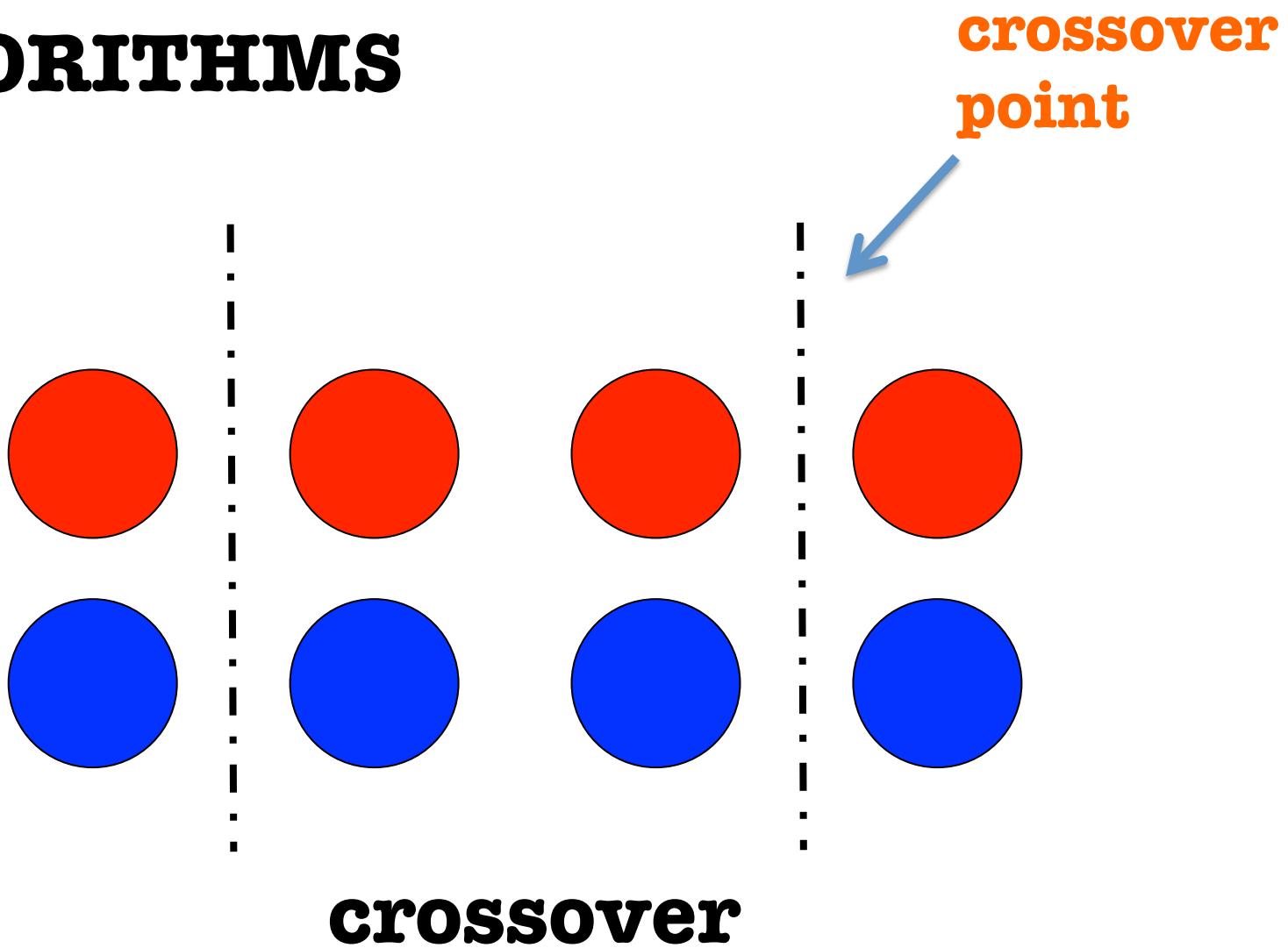


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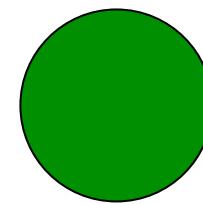
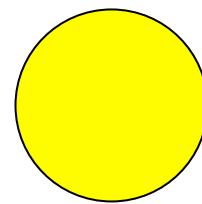
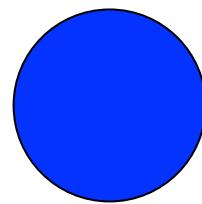
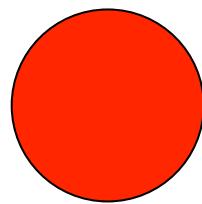
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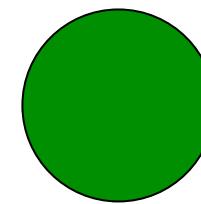
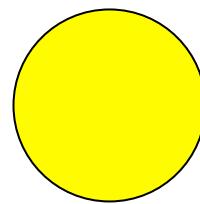
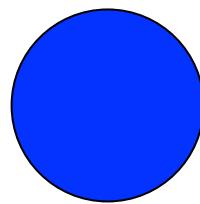
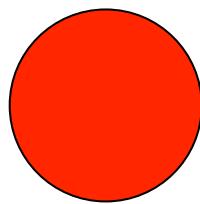
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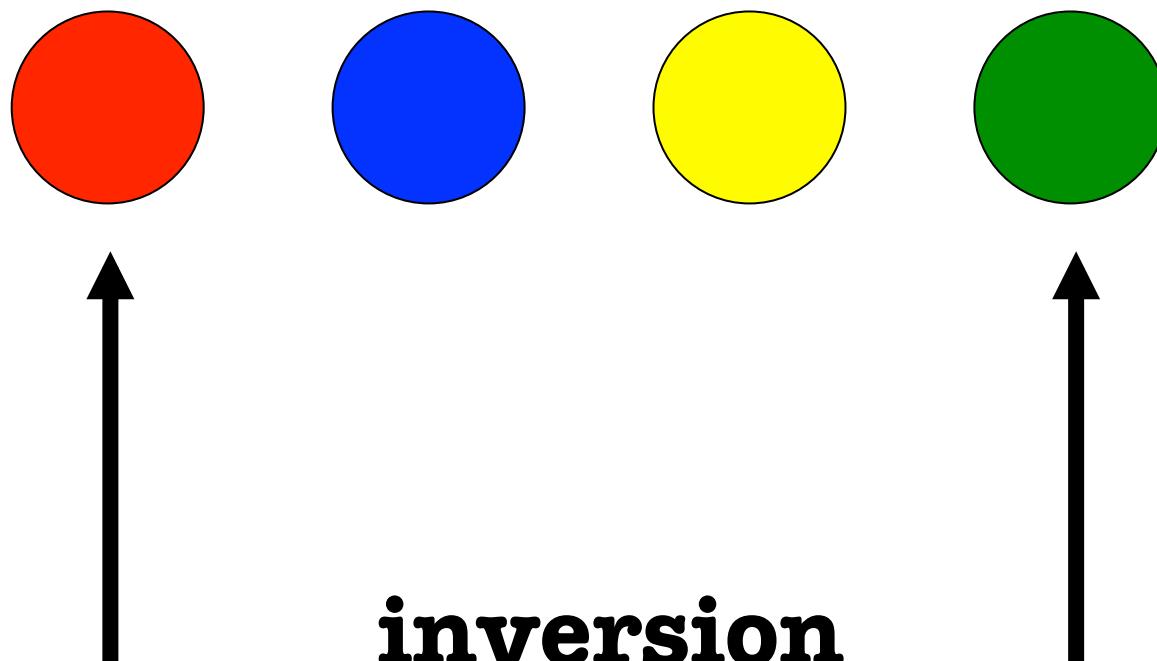


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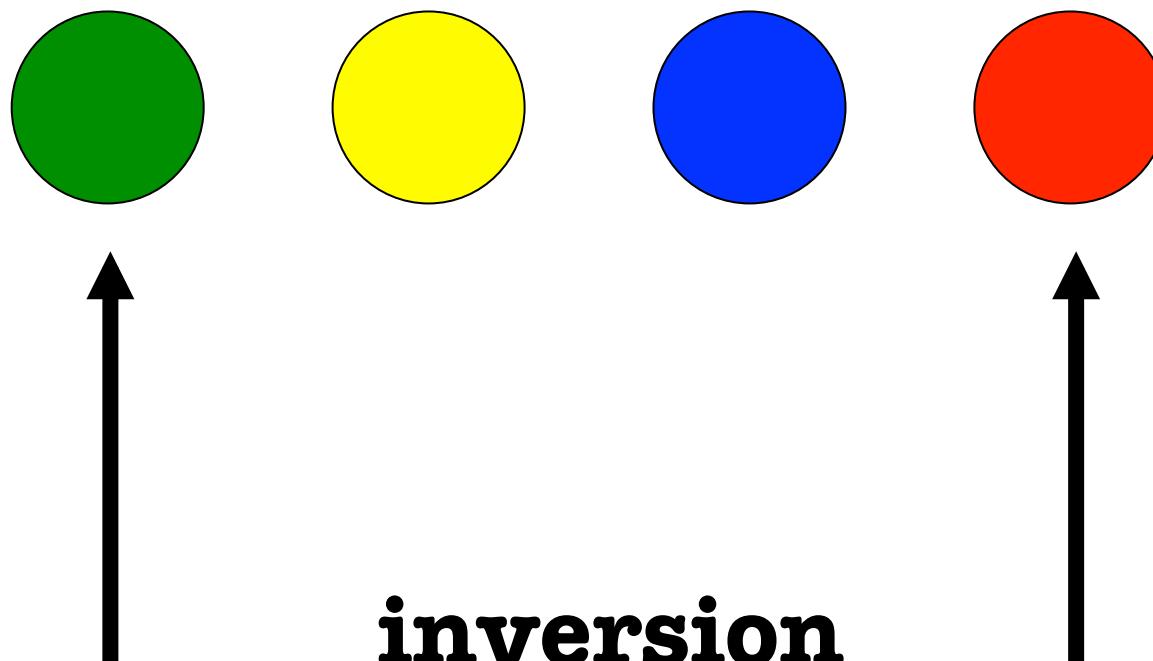


inversion

GENETIC ALGORITHMS

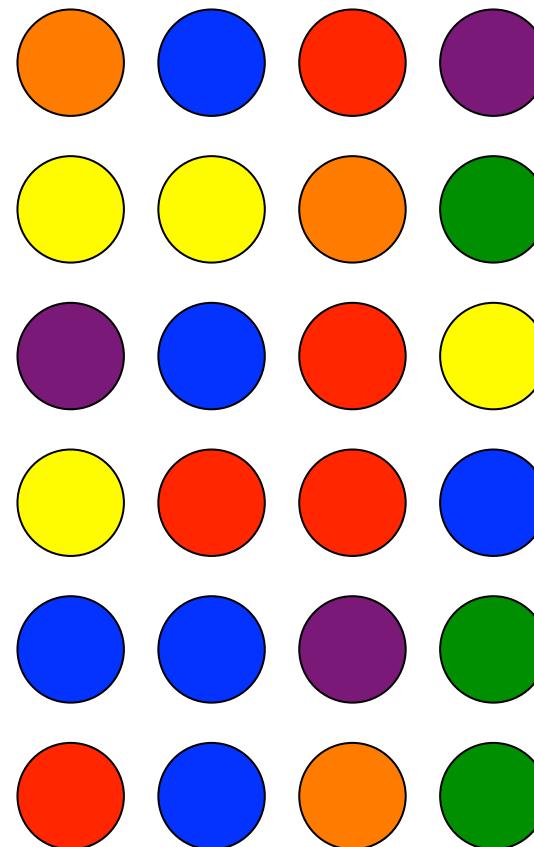
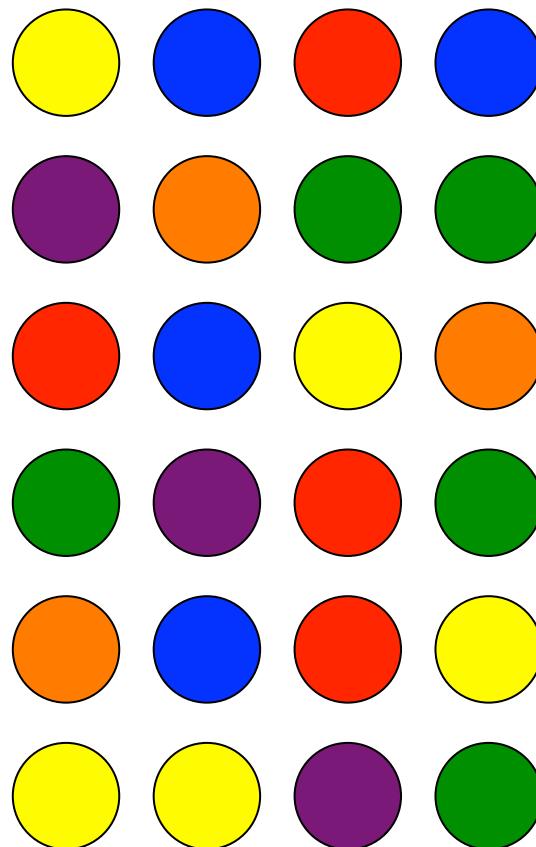


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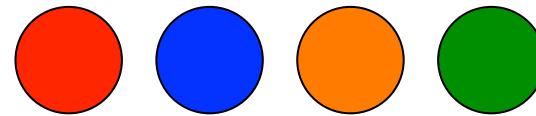
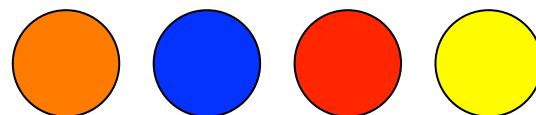
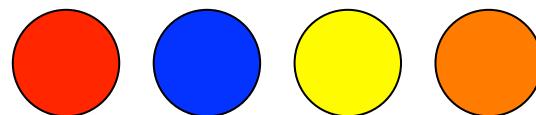
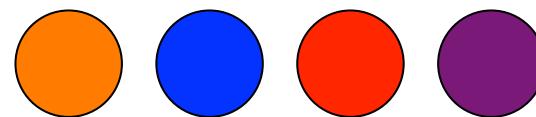


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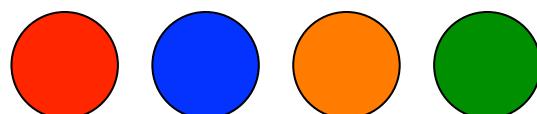
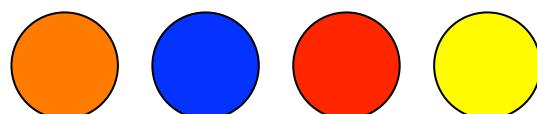
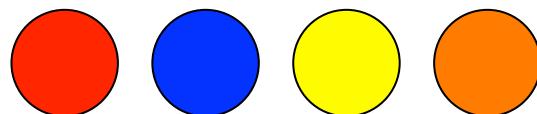
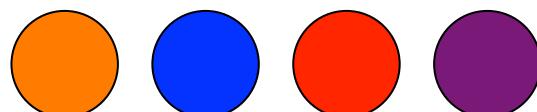
GENETIC ALGORITHMS



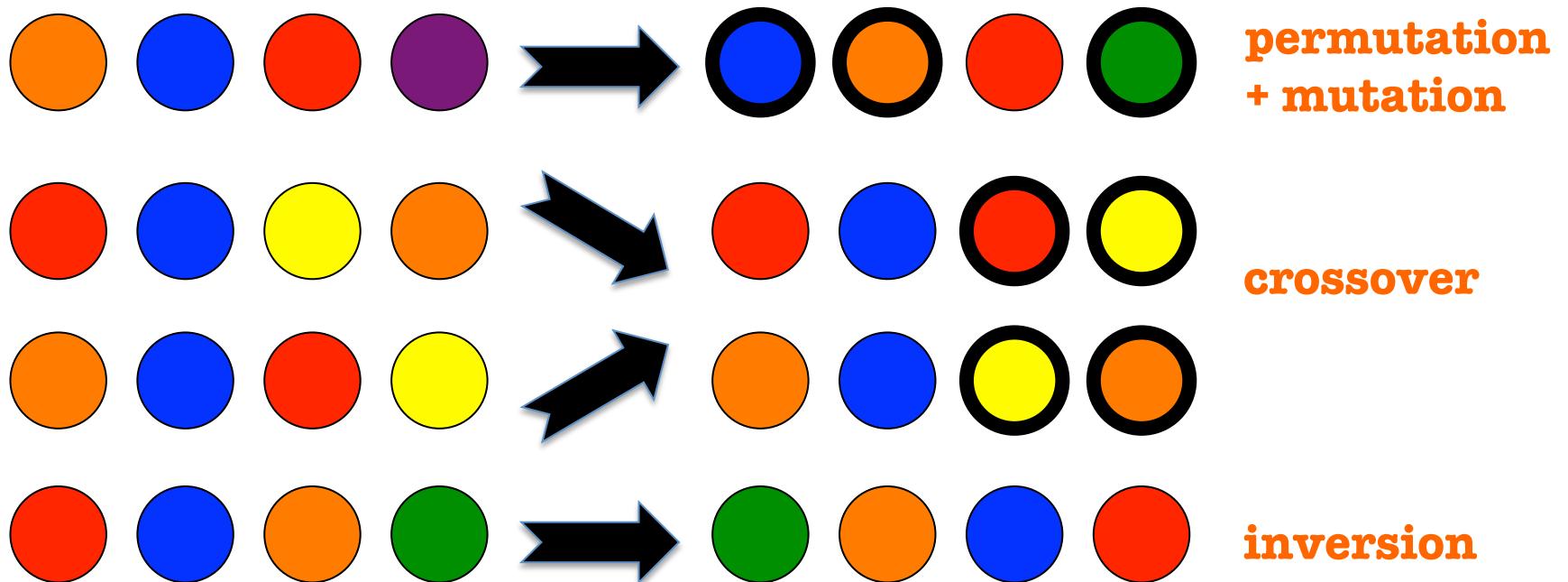
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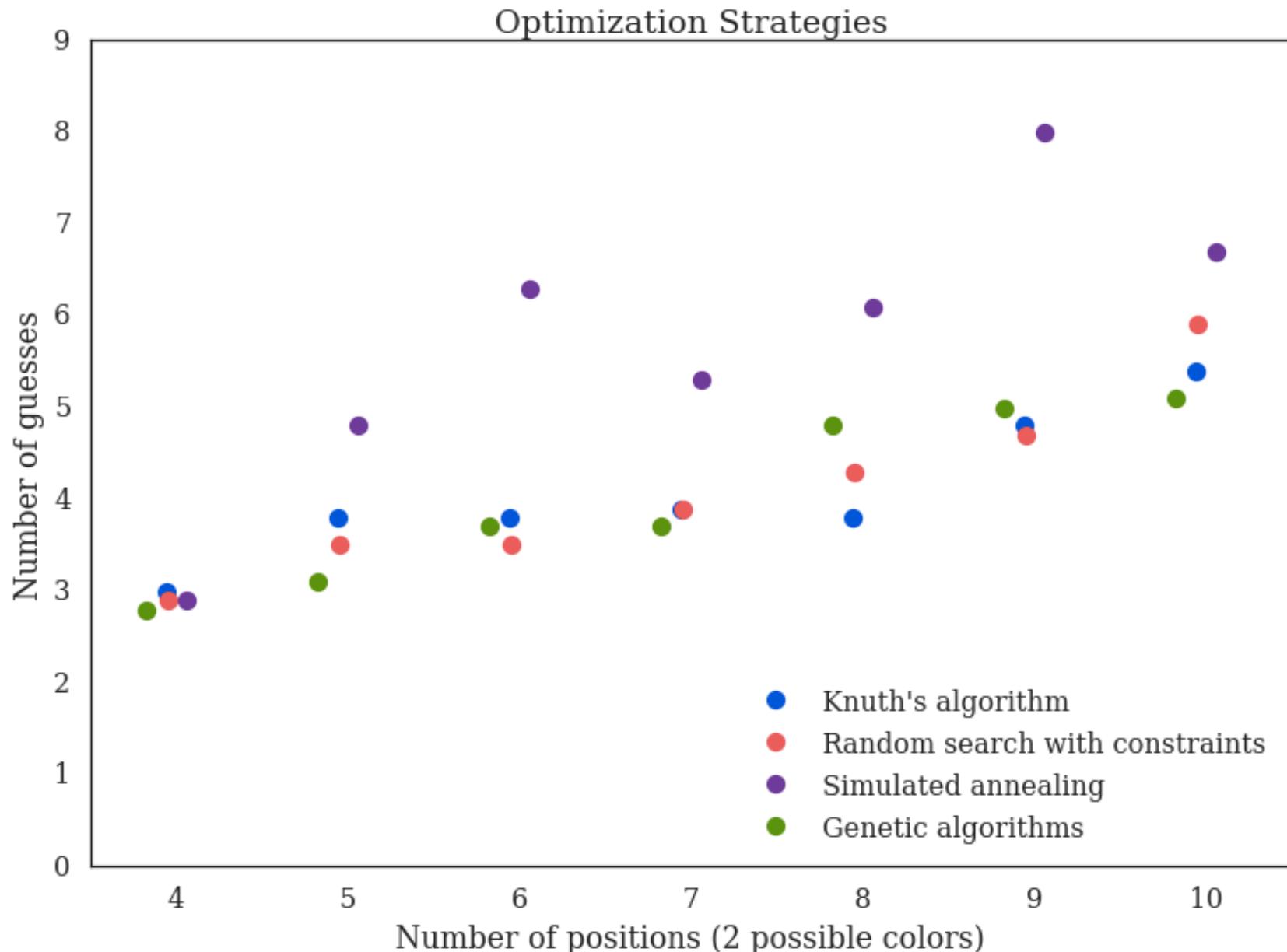
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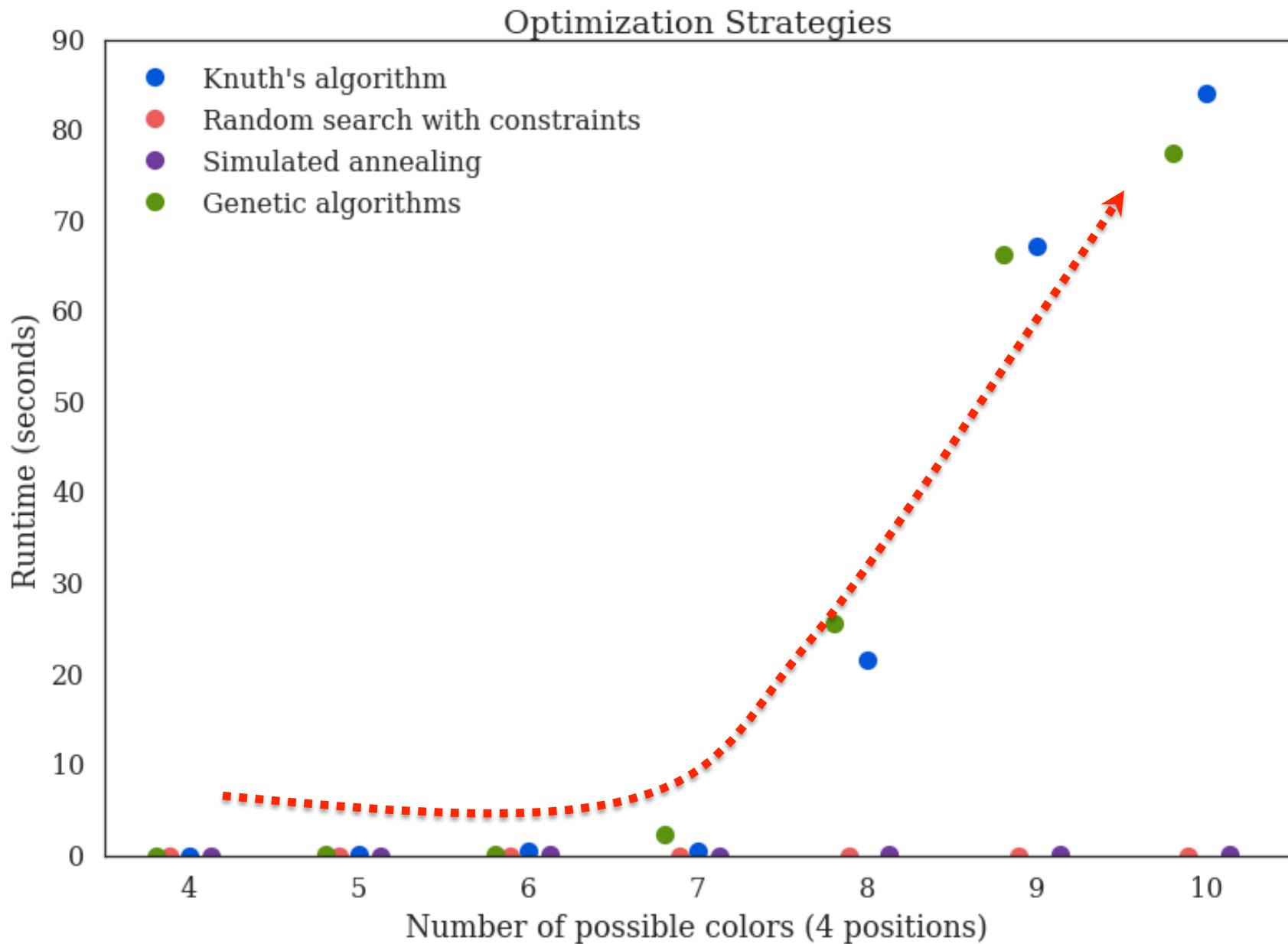
GENETIC ALGORITHMS



RESULTS: Guesses



RESULTS: Runtime



CONCLUSIONS

- Exhaustive strategies:
Colors \uparrow = Runtime $\uparrow \uparrow$
- Stochastic strategies:
 - Lower runtimes
 - Similar amount of guesses
- Stochastic techniques make playing scaled-up Mastermind in finite time feasible

Thanks for watching!