Swarm Intelligence H-414

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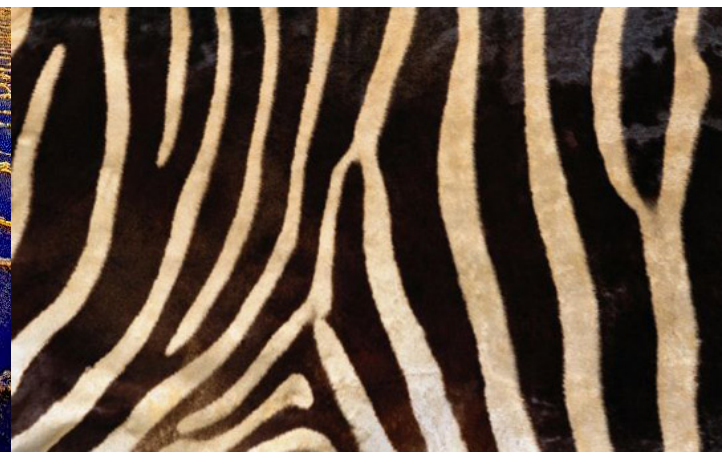
Pattern Formation

A pattern is an arrangement of objects displaying a mathematical, geometric, or statistic relationship

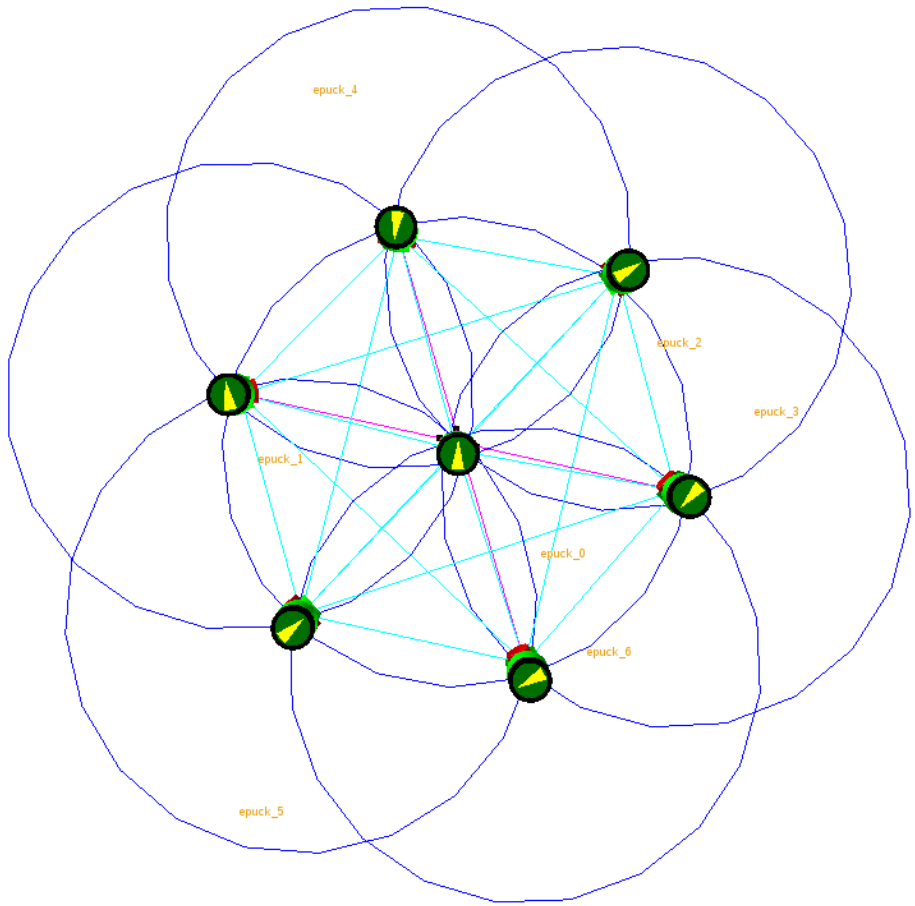


Pattern Formation with Mobile Robots

Pattern formation is useful for:

- covering an area with a fixed number of robots
- achieving a certain network topology
- flocking (collective motion)

Pattern Formation with Mobile Robots



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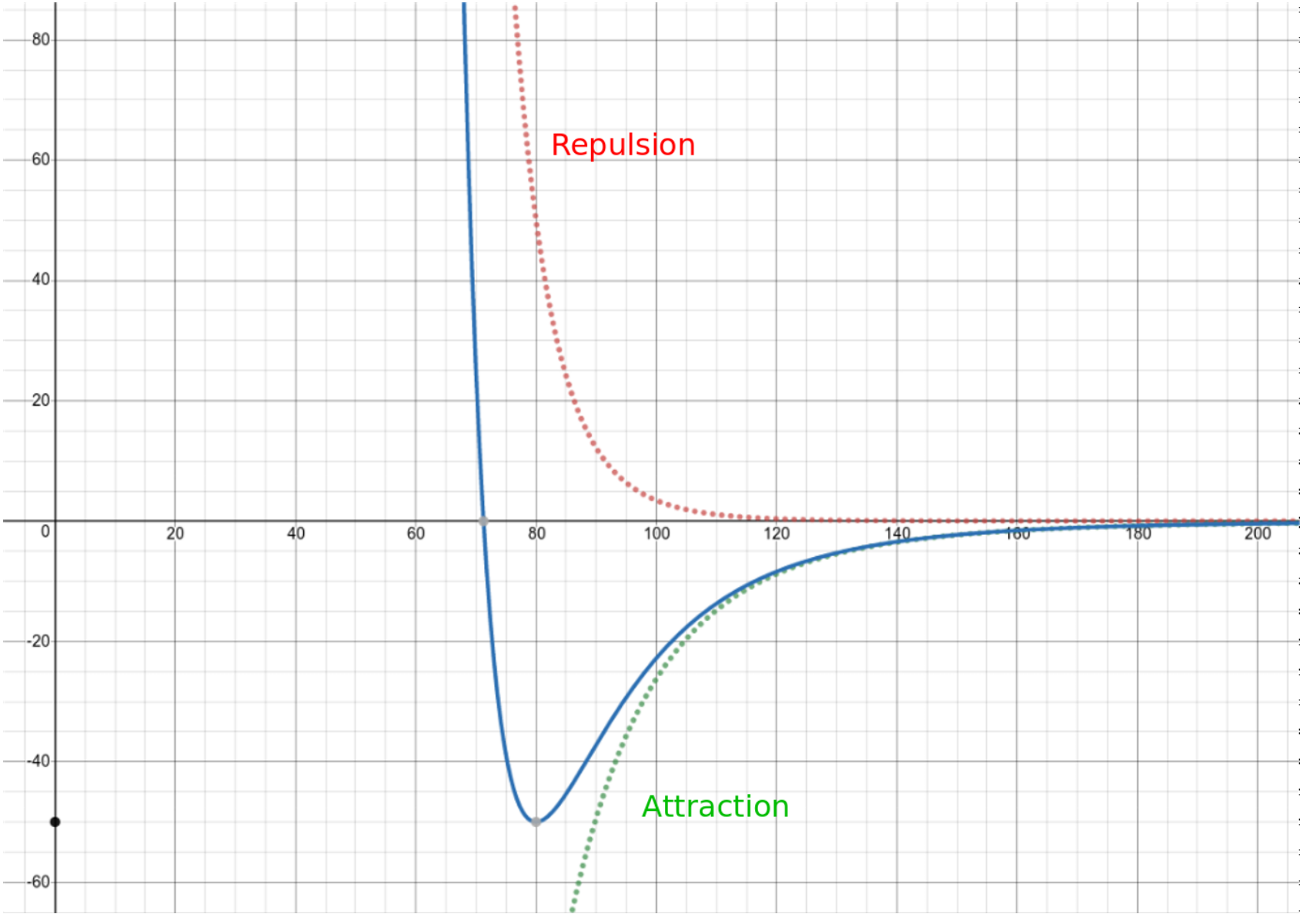
- In physics, the derivative of a potential is a **force**
- We transform the force into wheels actuation
- This way, the robots tend to go to the **minimum energy configuration**

The Lennard-Jones Potential



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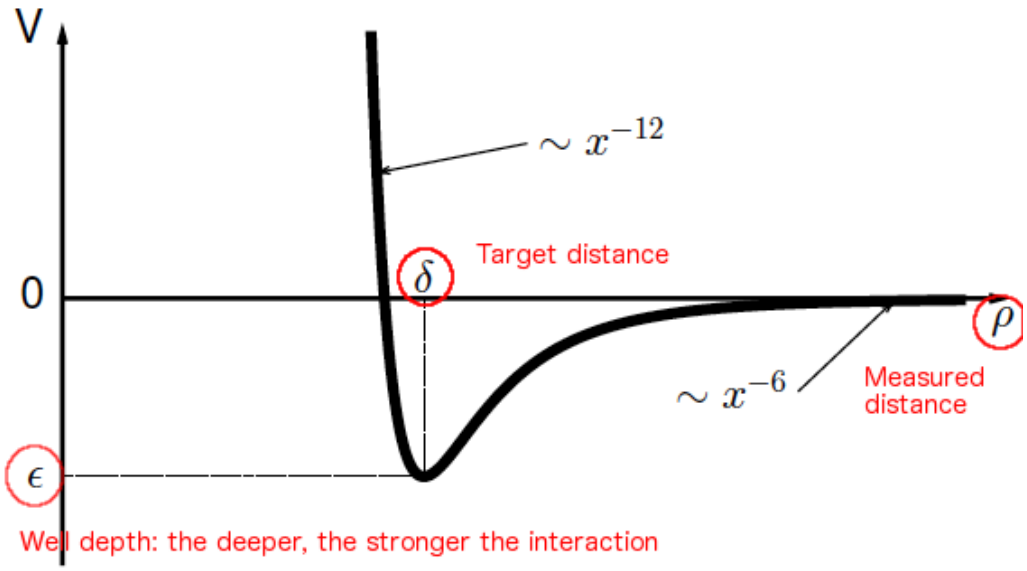

From the potential:

$$V(\rho) = \epsilon \left(\left(\frac{\delta}{\rho} \right)^{12} - 2 \left(\frac{\delta}{\rho} \right)^{6} \right)$$

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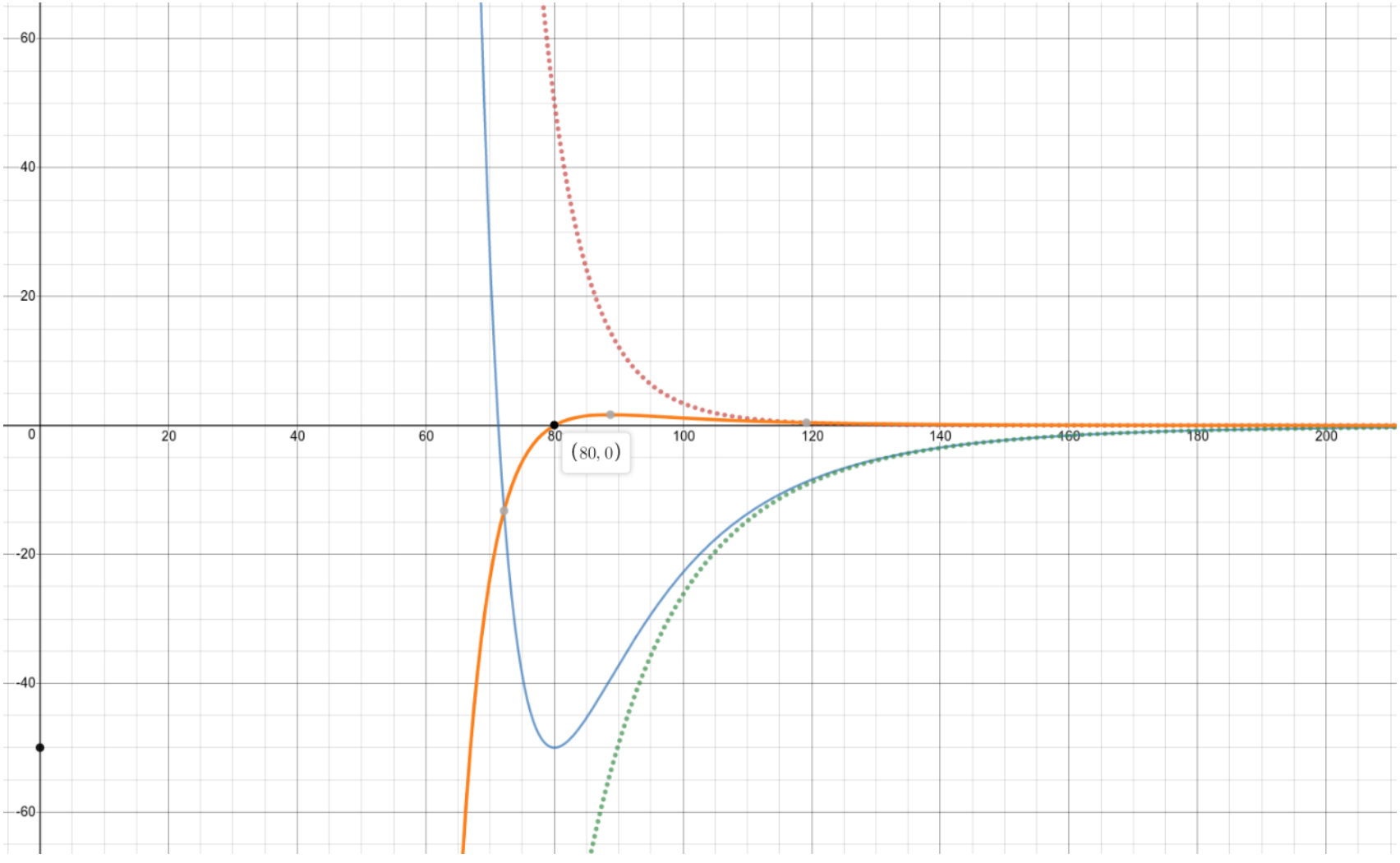
We can derive the force:

$$F(\rho) = -\nabla V(\rho) = -\frac{12\epsilon}{\rho} \left(\left(\frac{\delta}{\rho} \right)^{12} - \left(\frac{\delta}{\rho} \right)^{6} \right)$$

Smaller exponential values could also work:

$$F(\rho) = -\nabla V(\rho) = -\frac{4\epsilon}{\rho} \left(\left(\frac{\delta}{\rho} \right)^{4} - \left(\frac{\delta}{\rho} \right)^{2} \right)$$

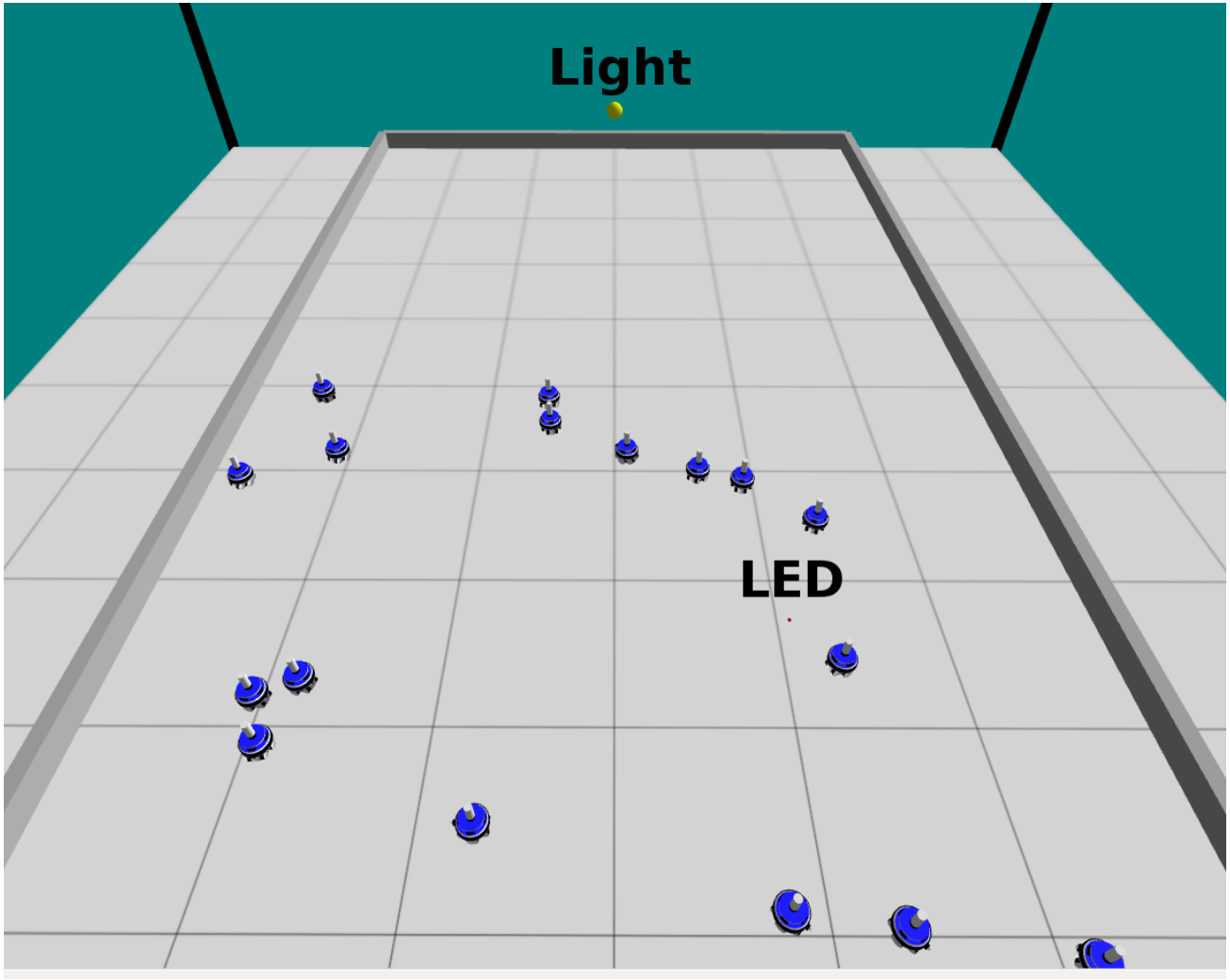
The Lennard-Jones Potential



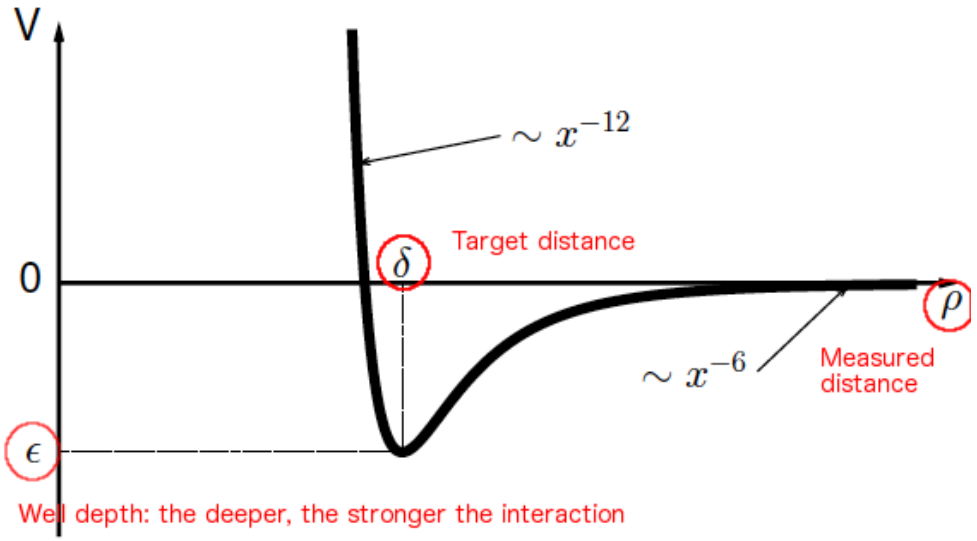
Pattern Formation: exercise

- Step 1: Implementation local $\rightarrow$ hexagonal pattern
- Step 2: Local + global $\rightarrow$ circular pattern
- Step 3: Flocking

Pattern Formation: arena



Step 1: hexagonal pattern



$$F(\rho) = -\frac{4\epsilon}{\rho}\left(\left(\frac{\delta}{\rho}\right)^4 - \left(\frac{\delta}{\rho}\right)^2\right)$$

1) Calculate the result force due to neighbors

```
for each neighbor i do
    calculate Lennard-Jones[i]
    direction += direction[i] * Lennard-Jones[i]
end
```

2) Transform **direction** into wheel actuation

Step 2: circular pattern

The robots should:

- maintain a certain distance between each other
- create a circular pattern “around” the red LED

Step 3: flocking

The robots should:

- maintain a certain distance between each other
- flock in a single group towards the light

Hint: it might be convenient to first create a static pattern and then start flocking