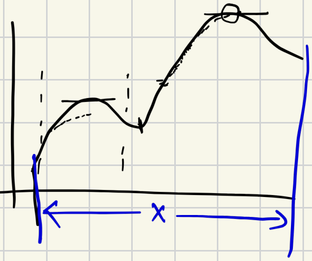
# Simulated Annealing




SA mimics this physical process to solve optimization problems. The temperature in SA controls the exploration of the search space

→ Initially, when the temperature is high, the SA Algo. can explore widely accepting even suboptimal solⁿ to escape local minima.

→ As the temperature decreases, the algo focuses more on refining the current solution

1> Search space (All possible solⁿ to the problem possible)
2> Energy (or cost) function. and constraints
3> Temperature (control parameter)

$T_0$ (high) ........ - $T_n$ (Low)
↓ Exploration ↓ (more conservative)

SA → 1> Initialization steps
a> Initial solⁿ (heuristic Approach)
b> Initial temperature (Manual)

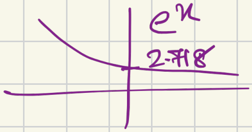
2> Iterative Improvement
a> Neighboring solⁿ (New solⁿ)
↳ change (small) to curr solⁿ
↳ check whether all constraint satisfied must

b> Calculate Energy / obj. fn.

3> Acceptance prob.
Boltzman prob. fn.

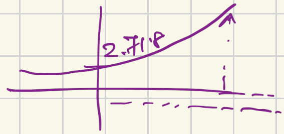
$$P(\text{accept}) = e^{-\Delta E/T}$$

$\Delta C$

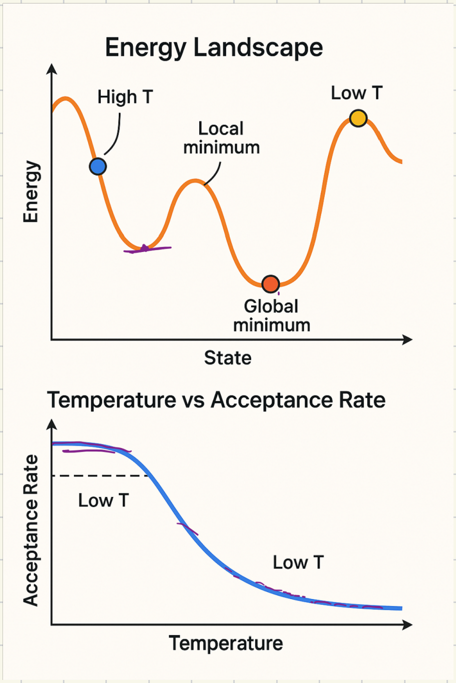



$\Delta E \geq 0$ (represent increase in cost or energy)

$\Delta E = 10$, $T = 100$




$$e^{-\Delta E/T} = e^{-10/100}$$
$$= e^{0.1}$$
$$= 2.718^{(0.1)}$$
$$= 0.90.$$




$\Delta E = 10$, $T = 1$

$$e^{-10/1}$$
$$e^{-10} \approx 0.000045$$

100

$\beta = 1$

100-~~1~~99

98

$\Delta C = 0$ $p = 1$

$\boxed{p = 0.5}$

$\boxed{p \leq 0.5}$

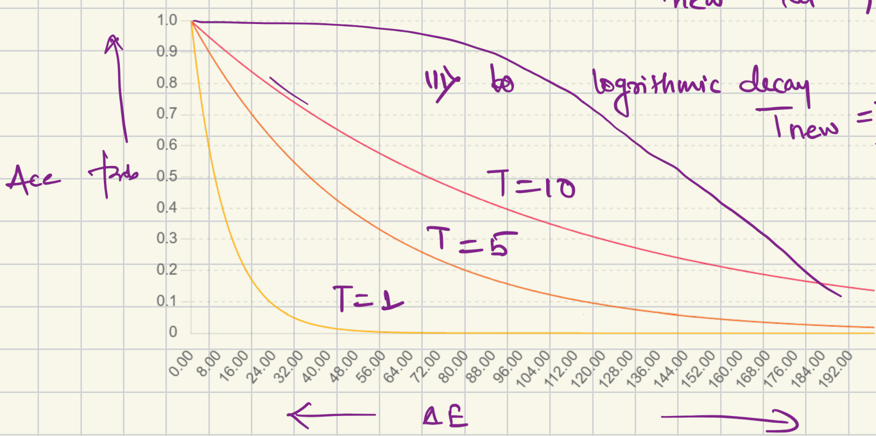
4) cooling schedule

i) Exponential decay $T_{new} = T_{old} * \alpha.$

$\underline{0 < \alpha \leq 1}$

ii) Linear Decay

$T_{new} = T_{old} - \beta.$




iii) ~~lo~~ logarithmic decay

$$T_{new} = \frac{T_{old}}{\log(k)}$$

$k$ → iteration number

5) Temperature Threshold. (stopping criterial)

i) Max iteration

ii) No improvemen in low temp.

i) Metaheuristic probablistic

ii) Approximate global optimization.

iii) random controlled search using temperature

iv) Large search spaces with many local minima.