CS161 Discussion 1A Examples

Here're some examples we went over during the discussions.

LISP
Exercise 1
Implement the following LISP function that reverses a list L.
Input '(a b c d)
Output '(d c b a)

```
(defun REVERSE (L)

)
```

Exercise 2
Implement the following LISP function that deletes the kth element from the list L.
Input '(a (b c) d (e f) g) 3
Output '(a (b c) d g)

```
(defun DELETE-K (L k)

)
```

Exercise 3
Implement the following LISP function that calculates the deep length of the list L.
Input '((a b) c ((1 2) d))
Output 6

```
(defun DEEPLENGTH (L)

)
```

Search Formulation

Exercise 1

Please formulate the River-Boat Problem as a search problem. Please define the Initial State (IS), Final/Goal State (FS), State Space, Actions, Successor/transition functions.

Exercise 2

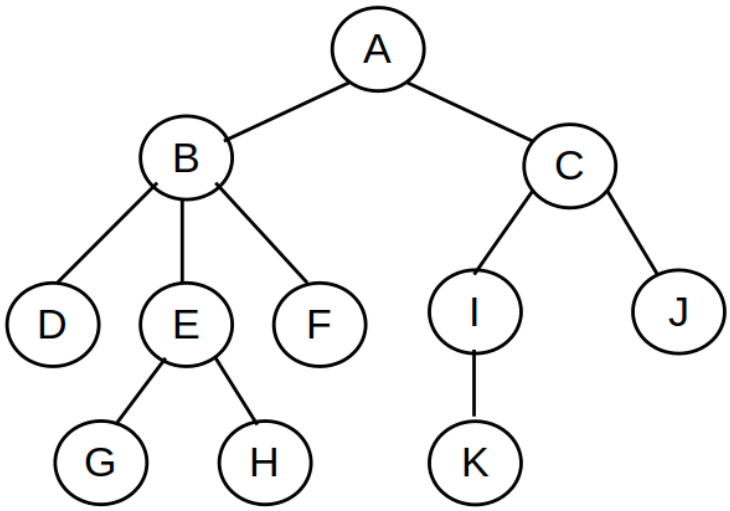
Please formulate the game Sudoku[1] as a search problem.

Uninformed Search

Exercise 1

Consider the following search tree. What will be the expansion order for the following uninformed search strategies? Assume left-to-right order and K is the goal state.

- BFS
- DFS
- Depth-limited Search with l=2
- DFID



Exercise 2

Let **b** := branching factor

d := depth of the optimal solution (finite)

m := max depth of the search tree (may be infinite)

l := depth limit

[1] https://en.wikipedia.org/wiki/Sudoku

For Uniform-cost Search (UCS),

e > 0 := minimal step/edge cost

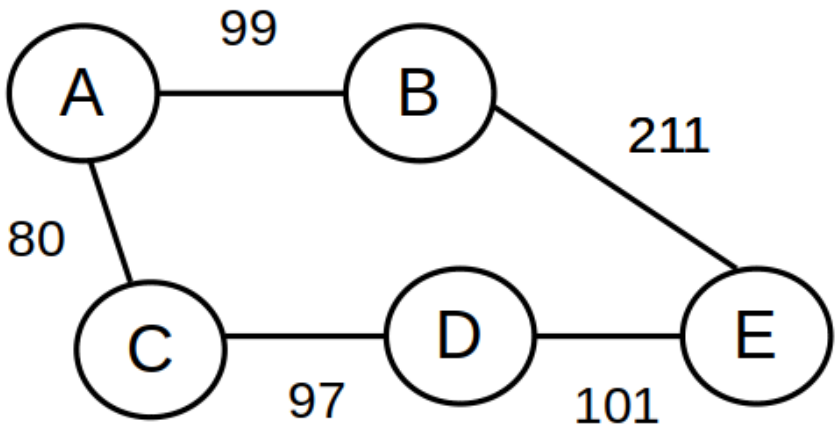
C* := optimal solution cost

Please fill in the following table.

Strategy	BFS	DFS	Depth-Limit	DFID	UCS
Complete?					
Optimal?					
Time Complexity					
Space Complexity					

Exercise 3

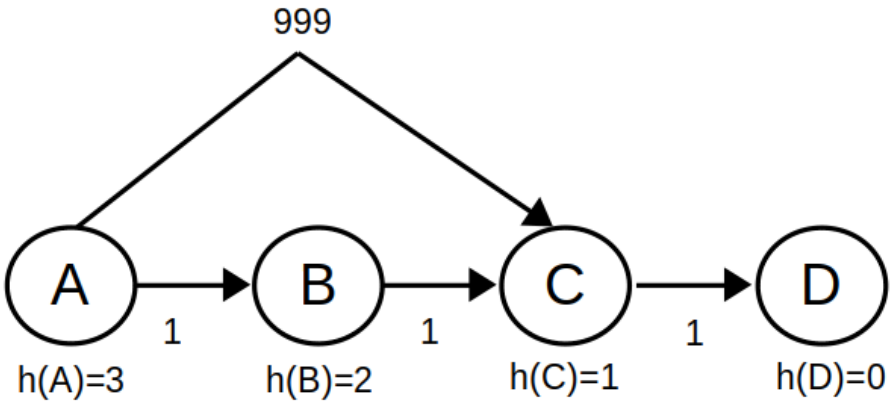
Please draw a search tree that finds the shortest path from A to E using **UCS**.



Informed Search

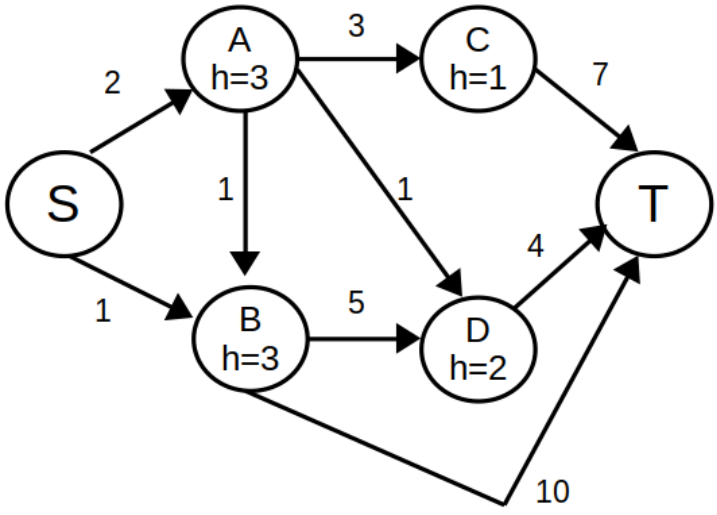
Exercise 1

Please draw a search tree that calculates the shortest path from A to D using **Greedy Best-first Search**. Is it optimal?



Exercise 2

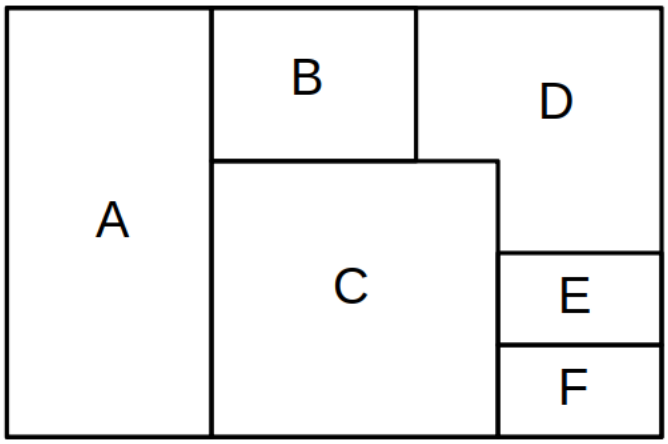
Suppose we want to calculate the shortest path from S to T in the following graph. The heuristic values for each node have been assigned according to a heuristic function *h*. Is *h* admissible? If so, please draw a search tree that finds the optimal path using A* search.



Constraint Satisfaction Problem (CSP)

Exercise 1

Consider the following map coloring problem. We want to color the regions with three colors {Red, Green, Blue} such that no adjacent regions get the same color. Please formulate it as a CSP problem (variables, domains, constraints). If we want to formulate it as a search problem, what will be the State Space, Initial State, Final/Goal State, and Actions?



Exercise 2

Please draw a constraint graph for the above map coloring problem.

Exercise 3

Please run a backtrack search with

- Variable ordering: Most-constrained variable; break ties alphabetically.
- Value ordering: least-constraining value; break ties by Red > Green > Blue where > means preferable.

Exercise 4

Same as Exercise 3 except

- Variable ordering: Most-constraining variable/degree heuristic; break ties alphabetically.
- Value ordering: least-constraining value; break ties by Red > Green > Blue where > means preferable.

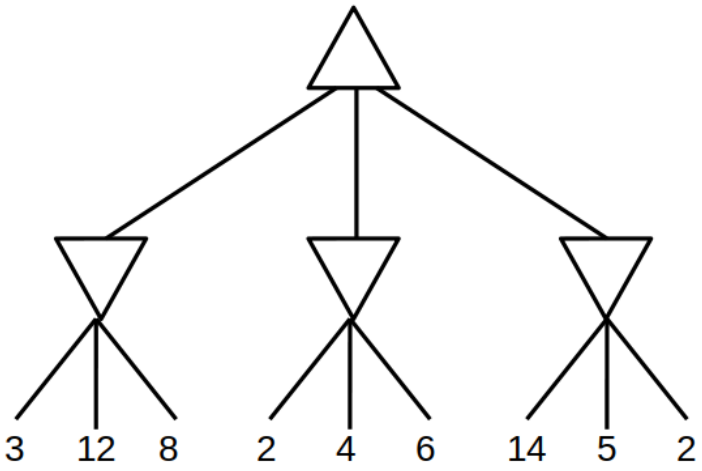
Exercise 5

Formulate the 4-Queens Puzzle as a CSP problem and run backtrack search to find a solution.

2-players Game

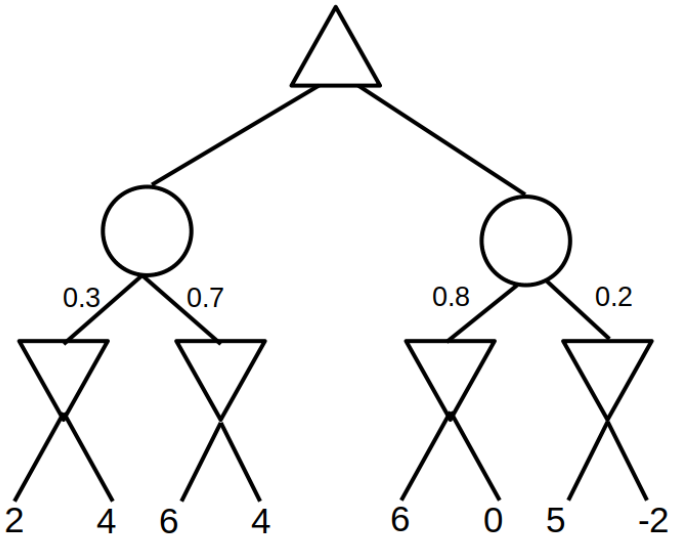
Exercise 1

Given the following game tree, what will be the payoff for the max player?



Exercise 2

Given the following nondeterministic game tree, what will be the payoff for the max player?



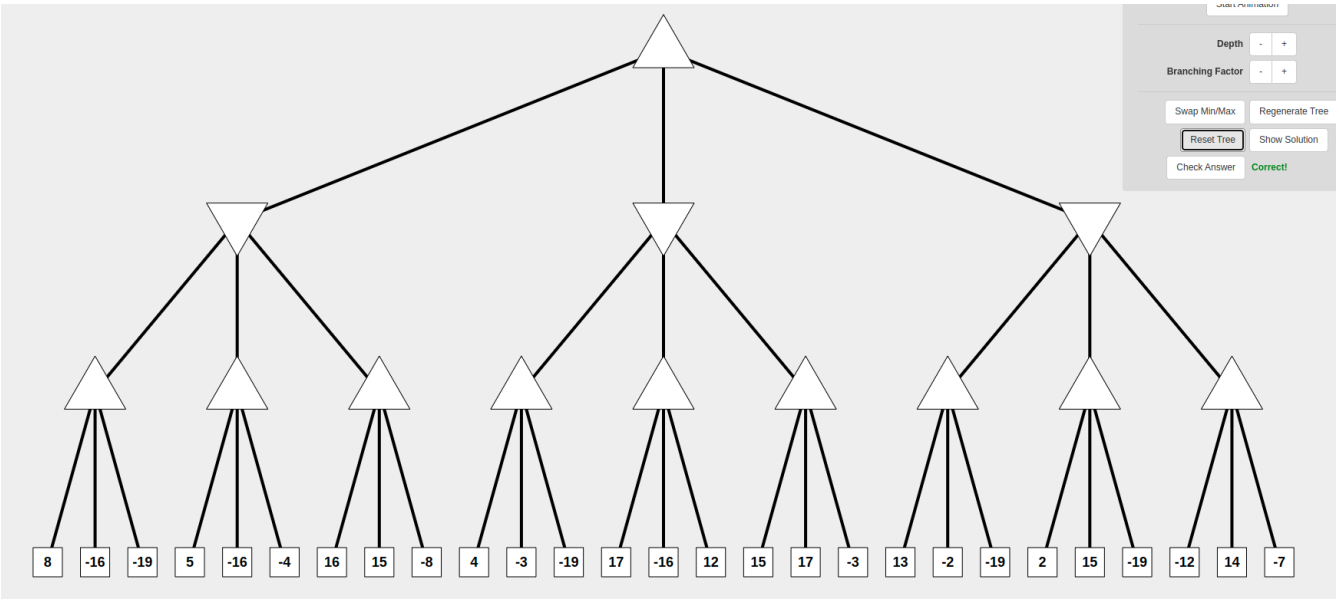
Alpha-beta Pruning

Please practice alpha-beta pruning from the following link

https://pascscha.ch/info2/abTreePractice/

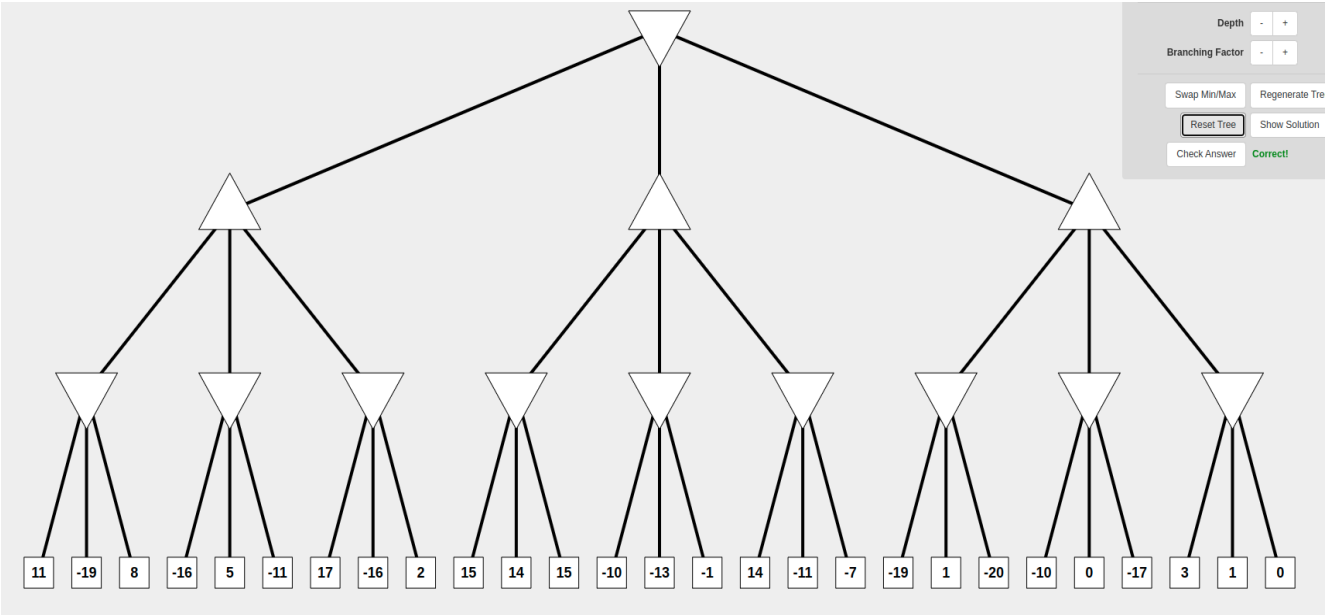
Exercise 1

Prune the following game tree.



Exercise 2

Prune the following game tree.



Normal Forms
Fill in the table below.

Form	Universal?	Tractable (SAT)?
CNF		
DNF		
NNF		
DNNF		
Horn Clauses		

Logic
Exercise 1
Convert the knowledge base KB to CNF form.

KB: $(A \vee \neg B) \Rightarrow C$
$C \Rightarrow (D \vee \neg E)$
$E \vee D$

Exercise 2
Use model checking (enumeration) to show that KB $\models \alpha$
KB: $\{A,\ A \vee B \Rightarrow C\}$
α: C

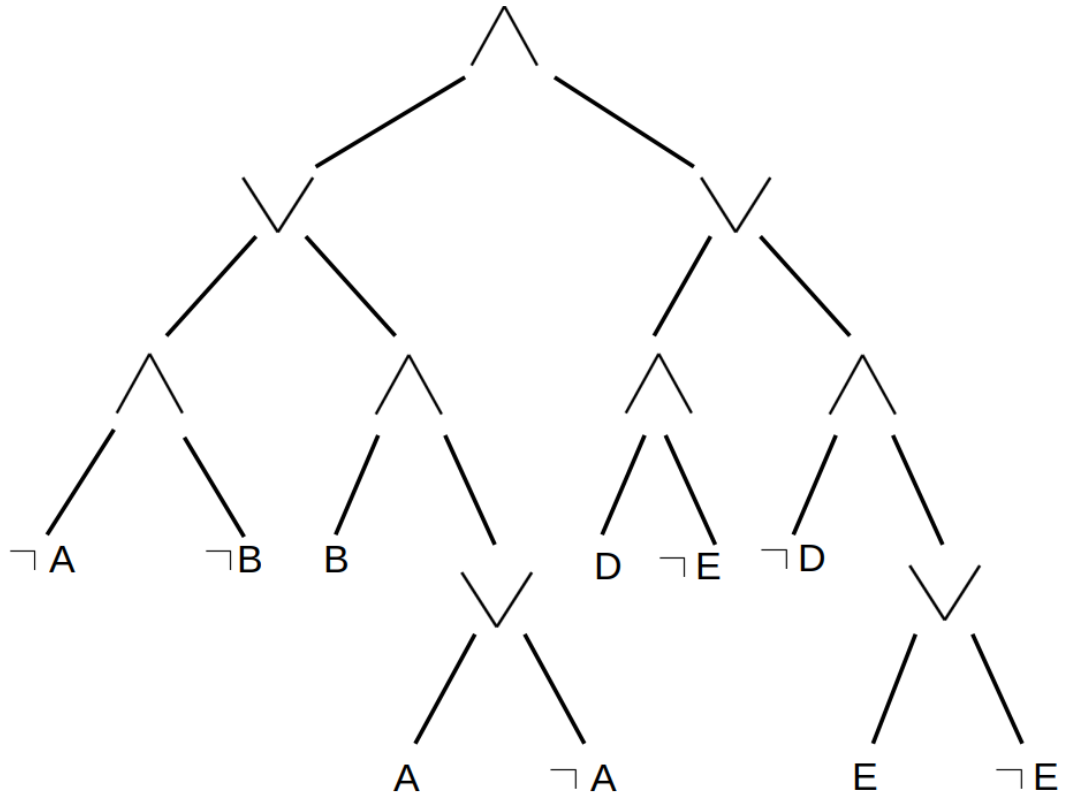
Exercise 3
Use resolution to show that KB $\models \alpha$
KB: $(A \vee \neg B) \Rightarrow C$
$C \Rightarrow (D \vee \neg E)$
$E \vee D$
α: $A \Rightarrow D$

Tractable Circuit

Exercise

Is the following circuit decomposable, deterministic, smooth?

If so, find the number of satisfiable assignments for the circuit. If not, explain why.



CS161 Dis1A Examples (Week 6-10)

1 FOL

1.1 FOL Basics

1. Please interpret the following FOL sentences in English
   - $\forall x \exists y \ Loves(x, y)$
   - $\exists y \forall x \ Loves(x, y)$
   - $\exists x \forall y \ Loves(x, y)$
   - $\forall y \exists x \ Loves(x, y)$
2. Please translate the following English sentences into FOL
   - Richard has at least two brothers.
   - Everyone has exactly one mother.
   - You can fool some of the people all of the time.
   - You can fool all of the people some of the time.
   - Richard has exactly two brothers.

1.2 FOL Inference

1. What is "Definite Clause"? How is it related to the "Horn Clause"?
2. Consider the following KB
   - $Person(y) \land Eats(y, x) \implies Food(x)$
   - $Student(x) \implies Person(x)$
   - $Student(Richard)$
   - $Eats(Richard, Apple)$

   Use *Forward Chaining* and *Backward Chaining* to show $Food(Apple)$.
3. Review HW6 for unification, conversion to CNF, and Resolution.

2 Uncertainty

2.1 Probability Basics

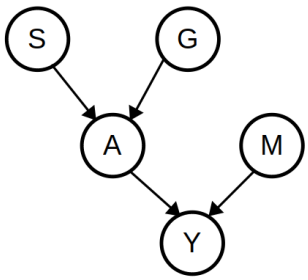
1. Prove $Pr(\alpha, \beta|\gamma) = Pr(\alpha|\beta, \gamma)Pr(\beta|\gamma)$
2. Consider a disease,
   - 1% of people have the disease
   - 90% of people who have the disease test positive
   - 8% of people who don't have the disease also test positive

   If Richard test positive, what's the probability that Richard indeed has the disease?
3. Puzzle: Monty Hall Problem.

2.2 Bayesian Network

Consider the following BN where

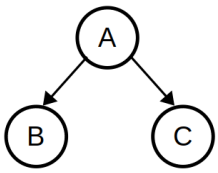
$$S \coloneqq \text{SAT score}$$
$$G \coloneqq \text{GPA}$$
$$A \coloneqq \text{Admission}$$
$$M \coloneqq \text{Major}$$
$$Y \coloneqq \text{Salary}$$



1. List all the Markov Assumptions.
2. How can we represent the joint distribution using CPTs?
3. $dsep(S, Y, M)$? $dsep(S, \emptyset, M)$?
4. Provide an example for each of the following queries:
   - Most-Probable Explanation (MPE)
   - Marginal (MAR)
   - Maximum a Posteriori (MAP)
   - Sensitivity Analysis

2.3 Encode a BN

Consider the following BN with CPTs



A	Θ_A
a	0.7
$\bar{a}$	0.3

A	B	$\Theta_{B\|A}$
a	b	0.2
a	$\bar{b}$	0.8
$\bar{a}$	b	0.4
$\bar{a}$	$\bar{b}$	0.6

A	C	$\Theta_{C\|A}$
a	c	0.9
a	$\bar{c}$	0.1
$\bar{a}$	c	0.5
$\bar{a}$	$\bar{c}$	0.5

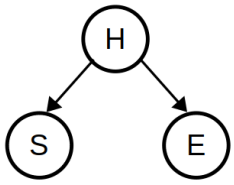
1. Encode the BN into logic sentences using indicator variables and parameter variables.
2. Assign weights to the literals such that WMC computes MAR.

2.4 Complexity

1. Difference between Tree, PolyTree, and Multiply-connected graph.
2. In general, what's the time complexity of BN inference?

2.5 BN Learning

Consider the following BN with a complete and incomplete dataset



id	H	S	E
1	T	F	T
2	T	F	T
3	F	T	F
4	F	F	T
5	T	F	F
6	F	F	F
7	T	F	T

id	H	S	E
1	T	?	T
2	T	?	?
3	F	T	F
4	F	F	T
5	T	F	F
6	F	F	F
7	T	F	T

1. For the complete dataset, what's the empirical distribution?
2. For the complete dataset, estimate the CPTs by counting.
3. For the incomplete dataset, run EM learning for two iterations assuming uniform initial CPTs. What's the learned joint distribution after two iterations?
4. See HW9 for Arithmetic Circuit (AC).

3 Machine Learning

3.1 Decision Tree

1. Is it always true that $ENT(X|Y) \leq ENT(X)$? How about $ENT(X|y) \leq ENT(X)$? When will $ENT(X|Y) = ENT(X)$?

2. Construct a decision tree for the following dataset.

id	Weather	Temperature	Play?
1	Sunny	Hot	No
2	Cloudy	Hot	Yes
3	Sunny	Mild	Yes
4	Cloudy	Mild	Yes
5	Rainy	Mild	No

3.2 Neural Networks

1. Why do we need activation functions?

2. What's the range for Logistic (sigmoid) and tanh?

3. Why do we want a validation set?

4. What's the difference between Gradient Descent and Stochastic Gradient Descent?