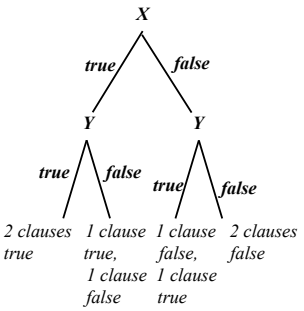
Problem Solving (Retake First Partial)

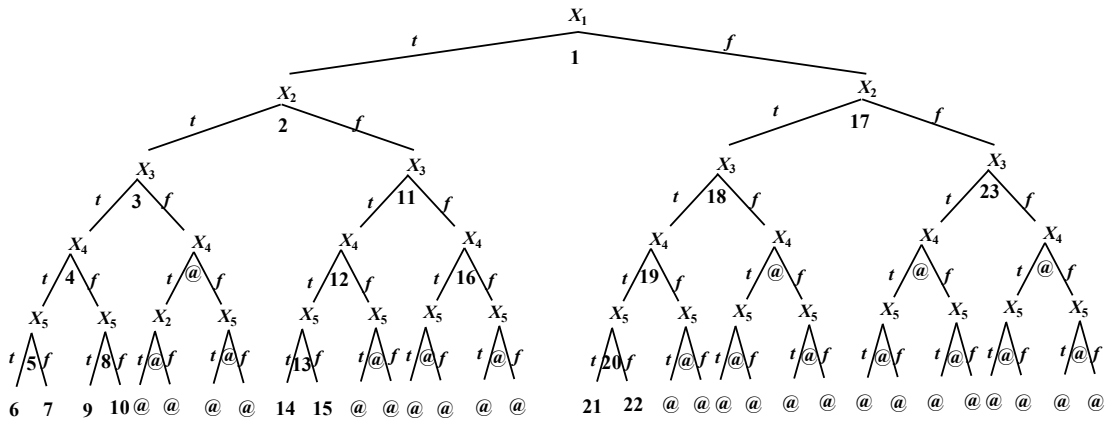
January 30, 2023, Classroom Q3/0003, 15:30–17:30

No notes, no communication.
The **number between brackets** [ ] indicates the points of the exercise.
Write the answer to the questions and each problem in **a different piece of paper**.
Always **justify your answer** (JYA); otherwise, it will not be considered.
Do not forget **to write your name** and coordinates (row and column) on every page.

1. **[2]** Often, a boolean formula is treated in a binary search tree, where each level is associated with a boolean variable, and its two possible values *true* and *false* are considered in the branches of the tree. For example, to count the number of clauses that may be satisfied in the $X \wedge Y$ formula (two clauses, X and Y), the tree on the right is developed, where *true* and *false* represent possible values of these variables. At the last level, the satisfied/falsified clauses are counted with the variable assignment corresponding to each branch.



To treat a Boolean formula with 5 variables X_1, X_2, X_3, X_4, X_5, a similar search tree is developed. An unknown algorithm traverses the tree. When the algorithm terminates, the visiting order is written at each node, while nodes not visited are marked with @, as indicated in the tree below. We want to discover this unknown algorithm. **Is it DFS? Is it BFS? Is it ID? Is it A*? Is it IDA*? Is it DFBnB?** Justify all your answers. Suppose that you have admissible heuristics or bounds as you need.



2. **[1]** A agent is located in the grid below, where the number at each cell indicates the initial value of the heuristic and black cells indicate obstacles, where the heuristic value is ∞. The agent can sense the contiguous cells in four directions: up, down, right and left (it can "see" what is inside of those cells, the heuristic value, if they are obstacles...). It can move one cell at a time, in one of these four directions. It is located in the central cell of the low row, and the goal is at the rightmost cell of the low row. It is requested to show the path followed by the agent to reach the goal and the new values of the heuristic in the grid, if the agent is controlled by:
   (a) the RTA* algorithm. JYA.
   (b) the LRTA* algorithm. JYA.

6	5	4	3	2
5	4		2	1
4	3	2 agent		0 goal

3. **[1]** When presenting local search, we have seen different methods to allow algorithms to escape from local optima. Identify and explain briefly three of them. JYA.

4. **[1]** A* does not get stuck in loops of the state space. Explain why and put an example. JYA.

5. **[2]** For the following set of clauses and assuming that we assign preferably the variable with the **smallest index** to **true**:

```
p cnf 6 9
-1 2 0
-1 -2 -3 0
-1 -4 -5 0
-2 5 -6 0
-4 5 6 0
3 4 6 0
4 -6 0
1 4 0
1 -4 0
```

   (a) Display the search tree followed by the DPLL algorithm, writing the reason for each unary propagation

   (There are only 2 decisions, hence 3 conflicts)

   (b) Represent the implication graph for the first conflict and compute all the UIP.

6. **[3]** The following drawing represents a configuration of the tic-tac-toe game (3 *en raya*) where no player has won (tie):

O	O	X
X	O	O
O	X	X

   (a) Write a formula whose satisfying assignments describe those configurations of a tie. Do not forget that player with "O" starts and then they play one turn each one. You can use cardinality constraints. Try to use as few variables as possible.

   (b) Write the variable assignment that represents the satisfying assignment for your formula corresponding to the drawing.

   Consider this intermediate state of the game:

O		
X	O	

   (c) Represent the situation as a partial assignment on your formula.

   Player "X" is forced to put an X on position $(3, 3)$. Explain how he can reach this conclusion using the formula you have described partially assigned.

   In the next situation, player "O" can win the game if he plays intelligently.

O		
	O	
X		X

   (d) Represent the situation as a partial assignment on your formula.

   Explain how he can detect where to play and win by looking at the formula partially assigned.