1. (i) Give a general technique for translating a finite discrete CSP to an equivalent propositional satisfiability (SAT) problem where in a finite discrete CSP each variable has a finite domain and each constraint is a finite set of tuples.

(ii) Use the translation to map the CSP below to a SAT problem.

\[ \langle C_1(x_1, x_2, x_3), C_2(x_1, x_3), x_1 \in \{1, 2, 3\}, x_2 \in \{1, 2, 3\}, x_3 \in \{1, 2, 3\} \rangle \]

where

\[ C_1 = \{(1, 2, 3), (2, 2, 3), (3, 2, 3)\} \]

and

\[ C_2 = \{(1, 2), (1, 3), (2, 1), (2, 3), (3, 1), (3, 2)\} \]

2. Consider the global cardinality constraint \( gcc_{l,u}(X) \) where \( X \) is a vector \((x_1, \ldots, x_n)\) of variables and \( l, u \) are functions from the union of domains \( D_1, \ldots, D_n \) of variables \( x_1, \ldots, x_n \) to non-negative integers. A tuple \( t = (a_1, \ldots, a_n) \in D_1 \times \cdots \times D_n \) belongs to \( gcc_{l,u}(X) \) iff \( l(a_i) \leq \#(a_i, t) \leq u(a_i) \) where \( \#(a_i, t) \) denotes the number of times the value \( a_i \) appears in the tuple \( t \).

(i) Express the alldiff\((X)\) constraint using \( gcc_{l,u}(X) \).

(ii) Consider the constraint \( gcc_{l,u}(x_1, \ldots, x_8) \) where for all \( i = 1, \ldots, 8, \) \( D_i = \{1, 2, 3\} \) and for all \( a \in \{1, 2, 3\}, l(a) = 0, u(a) = 2 \). Is this constraint hyper-arc consistent?

3. Compare WalkSAT and Novelty algorithms.

(i) Give a setting for the parameter \( p \) such that Novelty is deterministic but WalkSAT is not.

(ii) Explain why Novelty is said to be greedier than WalkSAT.

4. Write an integer program such that variables \( x_1, x_2 \) can have only values 0 or 1 and variable \( x_3 \) has the value of the Boolean function \( xor(x_1, x_2) \) in all feasible solutions.