1. Listen to me explain what *scheduling problems* are.

   Glossary:

   - There are n *jobs* and m *machnes*.
   - Jobs are defined by their *processing times* p_{ij} for $i \in [1, m]$ and $j \in [1, n]$ which indicates how long does job j run on machine i.
   - A *schedule* is an assignment of jobs to machines.
   - The *makespan* of a schedule is the last completion time over all machines.

2. In SCHEDULING ON IDENTICAL PARALLEL MACHINES, commonly known as $P||C_{\max}$, we have τ different job types which are only distinguished by their running times $p_1, \ldots, p_\tau$ where p_i is the processing type of job of type i on any of the m machines, and their multiplicities $n_1, \ldots, n_\tau$. Meaning that there are n_i jobs of type i, and $\sum_{k=1}^{\tau} n_k = n$ jobs in total. The goal is to find a schedule of minimum makespan.

   Give an integer programming formulation of $P||C_{\max}$ which has size bounded by τ and m. So the number of variables and constraints in the program should be bounded by a function τ and m. (And numbers in the program should be polynomial in the input size and a function of τ and m. This is to prevent you from somehow encoding the entire problem into a one variable of the program.) How small of a formulation can you find?

   From your knowledge of parameterized algorithms for INTEGER PROGRAMMING, what is the running time of the algorithm you obtained?

3. In the k-VERTEX-DISJOINT PATHS problem, we are given a graph G, and a set $P = \{(s_i, t_i)\}_{i=1}^{k}, s_i, t_i \in V(G)$, and the goal is to find k vertex disjoint paths between s_i's and t_i's. Meaning that the solutions is k paths $P_1, \ldots, P_k$ such that the endpoints of P_i are s_i and t_i and P_i's should be vertex disjoint.

   Give an FPT algorithm for parameter neighbourhood diversity for k-VERTEX-DISJOINT PATHS.

4. In the PRECOLORING EXTENSION problem, we are given a graph G where some vertices are precolored, and an integer c. The goal is to find a c-coloring of graph G which respects the precoloring which you can assume is a proper coloring.

   Give an FPT algorithm for parameter neighbourhood diversity for PRECOLORING EXTENSION.