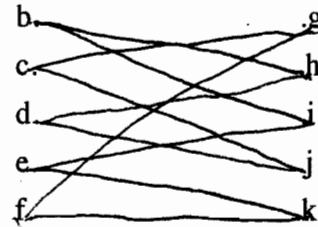


1. Give the cycle structure representation for a 80 degree rotation of the corners of an 9-gon.

2. a) Construct the matching network and make a flow corresponding to the partial matching  $c-j, d-h, e-i, f-k$ .

b) Apply the Augmenting Flow Algorithm (show ALL labels) and from it obtain a 5-edge matching.



3. Consider the game of Nim on the right.

a) What is the Grundy number of the initial position

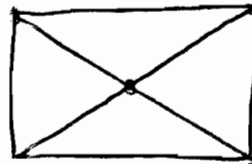
b) Make moves to get into a kernel position using pile 4 and pile 3.

c) Make a move to get into a position with Grundy number equal to 2

d) Suppose that 1 or 2 or 4 sticks can be removed at a time, determine the Grundy number of the initial condition and then make a move into the kernel.



4. Give an expression for the pattern inventory of 2-colorings of the *edges* of the unoriented figure on the right (rotations and flips allowed).



5. I. In the following table of remaining games, it is possible for the Bears to be outright champions (not co-champions) if they win all remaining games? Build the appropriate network model. Answer the question with a feasible flow in the network you created or with an explanation of why one is not possible. If there are co-champions with the Bears, who are they?

Team	Wins to date	Games to play	with Bears	with Lions	with Tigers	with Vampires
Bears	21	6	—	1	2	3
Lions	25	6	1	—	3	2
Tigers	25	6	2	3	—	1
Vampires	22	6	3	2	1	—

6. a) Find a spanning-tree solution to this transportation problem.  
 b) Find a set of prices based on this initial solution.  
 c) Find an entry (edge), currently unused, whose use would lower the cost of the solution  
 d) Find a new spanning-tree solution using the edge found in c)

	Store			Supplies
	1	2	3	
Warehouse 1	5	4	3	70
Warehouse 2	7	5	7	10
Warehouse 3	4	3	4	60
Demands	40	60	40	